USES OF ANIMALS.

THE

USES OF ANIMALS

IN RELATION TO

INDUSTRY OF MAN:

BEING A COURSE OF

LECTURES DELIVERED AT THE SOUTH KENSINGTON
MUSEUM.

BY

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PREFACE.

The first six of these Lectures were delivered at the South Kensington Museum, by the permission of the Committee of Council on Education, to whom my thanks are due for placing at my disposal for this purpose the lecture theatre of that institution. My notes had been prepared for the delivery of the second course, when it was thought desirable to discontinue any further systematic efforts for rendering available for purposes of education the collections placed under my superintendence. In order, therefore, not to break faith with the public and my publisher, I have been induced to throw together the notes I had made for these lectures, and those I had made for a course at the Royal Institution of Great Britain, on the Relations of the Animal Kingdom to the Industry of Man, so as to complete the course of twelve lectures.

In the second course of lectures I have treated the subject of the uses of animals to man more systematically than in the first, and I have thus been able to refer more particularly to those animal products which are used in medicine, and thus to supply the student of medicine with an outline of medical zoology.

I can hardly expect that I have been able to afford any practical information to those who are engaged in occupations dependent on animal products, but I hope that these lectures may bring before their minds some facts which will convince them of the importance of having those whom they employ taught the elementary principles of those sciences which explain the nature of the materials of their every-day work.

8 SAVILE ROW, W.

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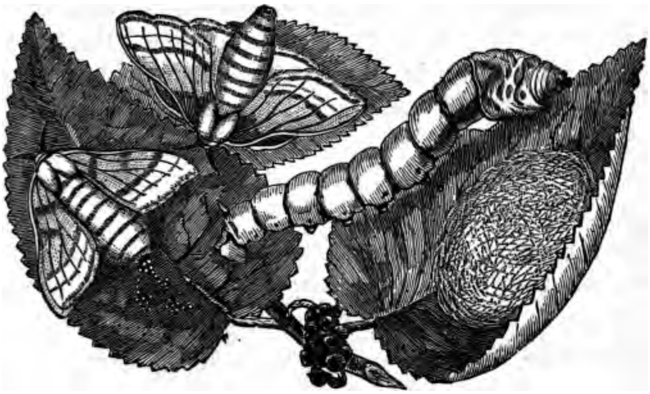


Fig. 1.

ON SILK.

In pursuance of an object that I had in view in delivering a course of Lectures on Food, I now purpose delivering a short course of Lectures on Animal Products used in the Arts and Manufactures. Most people are, perhaps, acquainted with the fact, that the Kensington Museum is a representative of two great departments which the Government maintains for the purpose of educating the great masses of the people of this country. It is called the Science and Art Department.

With the Art Department I have little or nothing to do, and would merely here commend it to your

earnest attention, and speak of it in terms of equal praise with the Department of Science, to which I am more immediately attached.

Standing between our Art Museum and our Science Museum, there is an additional Museum, which has more particularly in view the teaching of the various branches of elementary knowledge which are brought before the young. It is, then, to the Science Collection that I wish more particularly to call your attention; and I would just say, in order that you may understand the position in which this collection stands in relation to other collections, that it is only one part of a great whole. We bring together Museums of Natural objects, as distinguished from objects of Art, with which man's hand and mind have had so much to do. With regard to these natural objects, they may be arranged in a variety of ways. There is, first, the Natural History Collection, in which are arranged the varied forms of minerals, plants, and animals. Such a collection is the British Museum, the intention of which is, to illustrate the varied forms of created objects which are found in the external world; but in the Museum at South Kensington, there is no attempt to illustrate so extensive a subject; but the object there kept in view is, the illustration of the particular uses of minerals, of plants, and of animals; and within the last few years, there has arisen in this country and other countries of Europe, a series of Museums to illustrate the uses of external objects to man. It has been found that man's advancement upon the earth is entirely due to the way in which

he uses these things; not so much to his exhaustive knowledge of the properties of natural objects as to his knowledge of particular facts, so as to apply them to his own wants. Hence we have Economic, or Trade Museums, representing first the raw materials of the mineral, vegetable, and animal kingdoms; and then representing them in the various processes of their manufacture.

The Governments of Europe have, more or less, recognized the importance of these Museums. Our own Government has been amongst the foremost in this respect. Thus, we have in Jermyn Street a Museum which not only contemplates the Geological History of Great Britain, but which also exhibits the various objects of the Mineral Kingdom used in the arts and manufactures. Thus, the materials used in the formation of pottery, of metallic works, and of bricks and other building substances, are represented there. Then there are the great Botanical Gardens at Kew, where we find not only living plants, but a great collection of the raw materials of plants used by man in the arts and manufactures: there also, to some extent, is an attempt to represent the manufacturing processes of vegetable substances. Then, in this institution we have the Animal Kingdom treated in the same way. We have a great collection of animal products which are used in the arts, and we have also examples of the various processes which the raw material undergoes before it becomes fit for the use of man.

In these Lectures I shall endeavour to show you what is the nature of the animal substances thus exhibited, and what are the processes through which they pass

in order to be used by man in the various purposes of life. But there is another view of the external world to which I would draw your attention. The external world supplies man with things which are not merely used by him to supply his artificial wants—such as clothes, houses, plates, teacups, and other things,—but it also supplies him with materials which he needs in common with the whole animal kingdom. There is the salt in the water, and the various other saline substances which we eat, from the Mineral Kingdom, for the supply of our natural wants. Then there are the productions of the Vegetable Kingdom—potatoes, cabbages, wheat, rye, and other substances used as food. Then we take the animal, we roast him and eat him; and in this way the Animal Kingdom supplies our natural wants.

I want you to see this parallelism:—On the one hand, Nature supplies us with the food which we take from day to day—and this is illustrated in our Food Collection; on the other hand, man is an artificial animal, dressing and using a variety of things, sometimes from the Mineral or Vegetable, and sometimes from the Animal Kingdom; and it is to the class of substances supplied by the latter for this purpose that I wish to draw your attention in this and the ensuing Lectures.

It is just as man gets to know the properties of natural products that he uses them, for his benefit, and becomes civilized by his use of them. I do not know that I can illustrate this use of the Animal Kingdom better than in things familiar to all of us. Who would think that the little cocoons

of the silkworm could ever be manufactured by man's ingenuity into the most highly-prized articles of dress, which have at all times distinguished the monarch and the senator from the common people, giving a more pleasing and sightly appearance to the human form than perhaps any other substance? Thousands of our fellow countrymen and fellow country-women are employed upon, and depend entirely upon the employment derived from these little cocoons. Who would have thought that all this depended, from the earliest times, upon the knowledge of the way to unwind the silk, to spin it, and to weave it? And then, having done all this, by his knowledge man is enabled to take a variety of substances from the mineral, from the vegetable, and from the animal kingdoms, and to stain the woven silk, giving it a variety of colours; and whilst he thus increases the beauty of the articles, he increases the desire and the demand for them. Just as man's intellect is employed in this occupation, so does it seem capable of expanding and obtaining higher results; so that we may say that just as the intelligence of man exhibits itself in various manufactured articles, so does his civilization become developed. When you go into a community of well-dressed, well-cared-for people, you know they are civilized. And upon what does that depend? It is not the ignorant man that is civilized — it is not the lazy man that is civilized: civilization can only occur in an intelligent, in an active and industrious community. I want you, then, to study a little more systematically the scientific principles on which the arts and manufactures employing animal substances

depend. I wish we had more systematic teaching of this kind than we have, and that it had fallen into abler hands to deliver this course of Lectures.

Now, before proceeding any further, I would just draw your attention to the distinction between animal and vegetable substances, on which much of the difference between animal and vegetable manufactures depends. I would first refer to the fact that the two sets of bodies are composed of different materials, and those materials are represented by those great primary compounds out of which, to a greater or less extent, plants and animals are naturally manufactured. Thus, taking plants, whether they are composed of vessels or of cells, such as those represented in this drawing (Fig. 2), we shall find that they are composed of a hard substance, which the chemists call *cellulose*, and which is ordinarily called *wood*, when it is formed into the trunks and branches of trees.

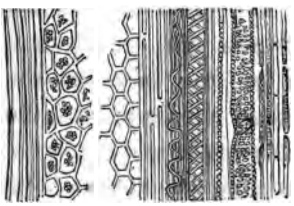


Fig. 2.

Now when we deal with the Vegetable Kingdom in our manufactures, we use this cellulose; when we cut down timber-trees, and saw them into boards, or when we take those delicate fibres for handkerchiefs, muslin dresses, and things of that sort, we deal with cellulose. But let us look again at these cells and fibres, when they have been worn—there is none of them wasted. After we have worn all our cotton and our linen to rags, the rag-collector picks them up for the purposes of the paper-maker. This cellulose, then, is converted into paper. Cellulose, however, exists naturally in the

world,—in the forests of Asia, Africa, and America, and there is plenty in our own wildernesses; and it is only a question of whether a man shall wear it first upon his back, or have it manufactured into paper at once. I believe the abolition of the paper duty would give the greatest incentive to young chemists and manufacturers to pursue the study of this subject, and to make such discoveries and improvements in the art of paper-making, that the paper-manufacturer might snap his fingers at rags, because of the abundance of available cellulose in the vegetable kingdom.

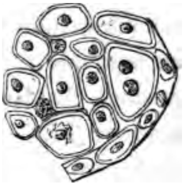


Fig. 3.

Now, when we examine the animal kingdom, we do not find any cellulose,—at least, not worth the attention of the manufacturer. Silkworms do not form it, nor does it exist in the horns of cattle, nor in the hairs of animals, nor the feathers of birds, nor in any of the animal products which we use in the manufactures; but we do find another thing, which is called *gelatine*, or the substance which we use in making glue, sizes, jelly, and the like: it always assumes the form of cells, but never has the properties of cellulose. The walls of the animal cells represented in Figs. 3, 4, and 5, are gelatine. Gelatine is soluble in hot water, while cellulose is not. A leg of mutton will boil to rags, but the leg of a table is insoluble in hot water.

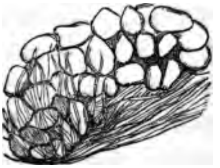


Fig. 4.

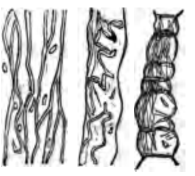


Fig. 5.

Gelatine is known by its specific gravity being greater than cellulose. Animal substances sink in water, but vegetable substances swim. Cellulose conducts heat with greater facility than gelatine: thus we are warmer in animal than vegetable clothing. Animal substances are stronger. These, then, are some of the distinguishing features between substances that are manufactured from the vegetable kingdom, and substances which are mannfactured from the animal kingdom. But you must not suppose that all animal substances are composed of a soluble gelatine. The horns, hairs, and hoofs of animals, for example, are not soluble in hot water. I shall examine the chemical composition of animal products more minutely when I come to speak of them. The artisan—the person who is working in these things—will do well to remember these facts, because out of some of them come important conclusions. Some dyes, for instance, which are absorbed by the animal tissue, will not be taken up by the vegetable fabric. The dyes of cotton are not the dyes of wool or silk; and thus out of these considerations arise general facts with regard to working in animal and vegetable substances.

I might detain you longer on generalities, but I will at once proceed to the particular subjects of my Lecture. I do not pretend to be a manufacturer, or acquainted with all manufacturing processes, but I do hope to be able to point out to you the advantages of studying the chemistry and natural history of the materials which you buy, sell, use, or manufacture. Now, looking at the animal kingdom as a whole, we see, in the first place, it supplies man with

food; but we have nothing to do with that upon the present occasion. We also use the vital force of animals, in our civilized life, as beasts of draught and burden. This is a kind of power which we constantly employ in horses, more especially in this country; but the elephant, the camel, the ox, and a variety of animals, are used in this way. I draw attention to this, but it is not what I want to treat of here; what I want more particularly to speak of here, is the way in which their products or parts are applied to the use of man. Take silk. Well, silk is woven into garments; it is woven in a variety of ways, and used for the purposes of textile fabrics. We have also other uses to which animal substances are applied: just as we use the solid portions of minerals and plants, so we use the solid portions of animals. There are, for instance, the bones, the horn, the hoof, the teeth, and a great many other parts, which are used by the manufacturers of solid materials of various kinds. Then again, we find that the chemistry of the animal is of a more complicated kind than the chemistry of the vegetable; and we obtain from animal substances compounds we cannot get from vegetable and mineral substances. We know that man is but a poor chemist in his laboratory, as compared with a plant. Take a spire of wheat, expose it to the action of carbonic acid gas and ammonia,—the little plant takes up those elements in the most marvellous way, and converts them to its own use in its wonderful laboratory; and, lo! there is the cellulose, the oil, the starch, the sugar, the albumen, and fibrine; and those little plants are doing this in every

moment of their existence, for the use of man and the animal kingdom. Thus the vegetable exercises an influence on the animal kingdom; and the animal takes up the starch and the sugar, the oil, the albumen, and the fibrine out of the plants, especially the latter, and they loosen and change their chemical affinities. An animal is more easily decomposed than a vegetable. If you doubt that, place a log of wood and a dog in a stagnant pool: the dog, in a very few days, will become in such a state that you would not like to come near him, while the wood may lie for years before it becomes decomposed. We intercept, then, as it were, the elements of animal bodies while they are undergoing these changes. There are skins: we throw tannic acid on them during their change, and they become leather; and there is the fatty matter, of which we make soap: we catch hold of these substances while the chemical change is going on in them, and we employ them and turn them to a hundred uses in the arts of life. Then there are certain things in the animal kingdom which come to us as disagreeable odours—such as the muscovy cat, with its stinking scent; yet this animal is caught, and we import for our perfumes 10,000 ounces every year of that civet which we dislike so much. Again, there is the musk from the musk-antelope, ambergris from the whale, and castor from the beaver, all of which are used as perfumes. Then there are dyes: cochineal insects and lac insects yielding the beautiful colours with which we dye our silks. Lastly, there are certain waste materials from animal manufactures, such as the waste of the silk and woollen manufactories, the refuse of bone manufactures, the offal of slaughter-houses,

and the refuse of our large towns; these can all be used; and when these things are studied, we find they are not refuse. When we come to consider these things, we shall find that God has made no waste in the world at all. There is a maxim, "Waste not, want not;" and we have wasted, and do waste; and I shall call attention to this waste in many things, and show that many branches of industry have sprung up from the utilization of this waste.

I begin with Silk, because it is an instance of the use man makes of the lower, or invertebrate animals. You will see, if you look at the whole animal kingdom, how very few conquests man has made among the lower animals. Nevertheless, among the lower animals, those that have no backbones, there are many of great service to man. Sponge is the skeleton of an animal belonging to the invertebrate group. There are a variety of shell-fish yielding us mother-of-pearl, cameos, and other objects of ornament. Then we come to the various forms of articulate animals, to which the insects, the crabs, and the lobsters belong. There are many useful products among these: there is the bee, yielding honey; the blistering fly, with its secretion so valuable to man in disease; and the leech, with his useful blood-sucking propensity. But I cannot at present say of these animals as I can of the higher class, that every part of them is useful: for instance, there is the horse, you can use every part of him; of his skin you can make leather, or you may boil him down and make him into jelly, or you may eat him; but no portion of him ought to be lost. It is, however, the insect tribe to which I wish

to draw your attention more particularly, in order to bring before you the material of one of the largest branches of our manufactures; namely, Silk.

Many insects undergo changes of a remarkable kind: there are some that change partly, and some that undergo no change at all. Some lay eggs, which produce creatures very much like their parents, while others produce creatures more or less like their parents; and others, again, produce creatures which are utterly unlike their parents. Take, for instance, the group to which the common moths and butterflies belong: these lay eggs, from which come larvæ that become insects unlike their parents, and which spin for themselves cocoons,—a sort of tomb,—and pass into things called chrysalides, in which state they lie for weeks, months, and sometimes even years; but at last the chrysalis bursts, and out comes the perfect insect—the butterfly or moth. And it is to these families that our silkworm belongs,—to a family known to naturalists as the family of *Bombycidæ*. To this family also belongs the *Saturnia Atlas*, which is the largest insect known, measuring eight, and sometimes nine, inches across its wings. Then, this family produces caterpillars, which form cocoons, or nests, composed of silken fibres, known by the name of silk. It is not, however, every species of this family of *Bombycidæ* from which we can obtain silk, although there are a number of them that yield a silken fibre just in the same way as our common silkworm. In the Museum there are a large number of specimens of silk obtained from other species of moths besides our common silkworm moth. That is an important

point to recollect. Circumstances may supply us with means by which we may obtain as large a supply from some other species as we do now from the common silkworm. There are difficulties in cultivating the common silkworm moth; and if we could find a hardier kind of moth for this purpose, it would be a great benefit. The more knowledge we have of these creatures, the more likely we are to discover and introduce new sorts and kinds, and thus increase this serviceable produce. It has not been by ignorance or accident that man has discovered the use of any of these things; but just as he has searched into nature, so has he been rewarded by discoveries; and in every step discovery upon discovery has been made, by intelligent men. If we expect to progress, we must cultivate our minds more and more, and bring them to bear on the practical arts of life.

The following is from the catalogue of the South Kensington Museum:—

"The Bombycidæ include the largest of all the moths yet known, the *Saturnia Atlas*, the extent of whose wings measures between eight and nine inches. The ground colour is a fine deep orange-brown, and in the middle of each wing is a large sub-triangular transparent spot: each of these transparent parts is succeeded by a black border, and across all the wings run lighter and darker bars, exhibiting a very fine assortment of varying shades. The upper wings are slightly curved downwards at their tips, and the lower wings are edged with a border of black spots on a pale buff-coloured ground. The antennæ are widely pectinated with a quadruple series of fibres, which have a very elegant appearance. This moth is met with in Southern India, and the Chinese tussah silk has been said to be obtained from it.

"Among the various moths found in Assam, and other parts of India which produce silk, are the *Bombyx Mori;* the tussah (*Saturnia paphia*); the eria, or arindy (*Bombyx Cynthia*, or *Phalæna*

Cynthia); the moonga (*Saturnia Assamensis* of Helfer), the joree (*Bombyx religiosa*, Helfer); and the *Saturnia Silhetica*, Helfer.

"Another species of *Saturnia* (*S. Selene*), the posterior wings of which are prolonged into a tail-like process, is common in southern India. Its chrysalis is enveloped in a silky covering, so like that of *S. paphia*, that it would probably be found to yield a strong and useful thread.

"The cossimbazar produces a large cocoon; but this worm will only produce silk annually.

"Desse is the small indigenous or native silkworm of Bengal, which may be produced nearly throughout the year. It yields silk of a bright yellow colour. The eggs are hatched and formed into cocoons in from fifty-five to sixty days in the November and March *bunds*, or seasons; from forty to forty-five days in the October; and from twenty-eight to thirty days in the April and June *bunds*.

"The nistry tribe of silkworms comprises three species—the madrassie, the soonamooky, and cramee. The soonamooky are the best: like the madrassie, they are very hardy, requiring little care, and not being at all choice in their food.

"The madrassie or foreign cocoons rank next. They produce silk of a greenish hue, much inferior to the desse or soonamooky, but the produce is large. The worm is distinguished from the desse by a black mark under the throat.

"The tussah silk-worms are reared in all the western forests, and there are three different kinds of the 'goottees,' or cocoons, collected in September; namely, the moonga, the most common, which produce a coarse thread, easily wound; the teerah, a smaller cocoon, with a firm thread, but not so easily wound, nor so much valued by the weavers; and the bonbunda, the largest of the wild silkworms: the thread being coarser, runs easier, and is, therefore, in more estimation by the weavers."

Now, some of these silkworm moths assume very splendid forms; we cannot, however, greatly admire the little moth to which we are so much indebted,—the *Bombyx Mori* (Fig. 1), which produces all this silk, and gives employment to a hundred thousand people in this country, and to millions in other parts of the world. In the drawing of our moth, you see it has dark marks on its wings.

Now, this moth deposits its eggs in the autumn of the year; it is hatched from the chrysalis in the cocoon, and the eggs, which are deposited in the latter end of the summer, will hatch the next spring. After they are hatched they form little worms, larvæ, or caterpillars, and many of you may have seen them, and perhaps kept them: they may be seen any day in May, in Covent Garden market; they go on for six or eight weeks in this condition, increasing in size, and as they increase in size they eat more and more, until at last we find them an exceedingly rapacious crew, devouring large quantities of the leaves upon which they live. They are at least two inches long before they spin their cocoons. During their growth they shed their skins, sometimes four and sometimes five times, before beginning to make their cocoons. By this process the creature is enabled to increase in size. This is the natural habit of moulting. Birds throw off their feathers at certain seasons; horses throw off their hairs; and so human beings are constantly moulting; for if you take a brush and brush your skin, a certain quantity of the epidermis will be brushed away. From day to day, from year to year, we moult our skin, and thus we throw off that matter which is no longer of use to us. This moth is called the *Bombyx Mori*, because it feeds on the mulberry. The *Morus nigra* is the species of mulberry that has been cultivated in Great Britain. Unfortunately for us, the silkworm always chooses to be hatched just before the time the leaves of the mulberry-tree come out, so that we have a difficulty in feeding them. It does not seem that we have

been able here, nor anywhere else, to retard their hatching. On this account we have had recourse to feeding them upon other substances. The mulberry-tree yields a milky juice, and we, taking the hint, substitute the lettuce and the dandelion, which both yield a similar juice, and the creatures will rather feed on these than die; but it is a fact that silkworms fed in their early condition on lettuce-leaves, never thrive like those always fed upon mulberry-leaves. Various attempts have been made to cultivate the silkworm in Great Britain. The black mulberry was early introduced, after the successful culture of silkworms on the Continent, and there are large orchards remaining which were planted at that time; but all attempts have failed to make the rearing of silkworms a paying speculation. Sometimes the young silkworms and the leaves will come out together, at another time the mulberry will persist in coming out a month later, and thus the cultivation in this country has been abandoned. At the same time, there is reason to believe that it might thrive in this country, as it succeeds in Russia and various parts of North America, and silk has been recently produced in Great Britain: but the question is, how can we obtain silk from our worms permanently, without any of that liability to the failure which has so frequently attended the attempts at cultivating silkworms in this country?

Now, I recollect that at various meetings of the British Association, a lady appeared from time to time, bringing specimens of silkworms and manufactured silk, endeavouring to show the members of the Association that it was possible to produce silk here; and I

recollect a very splendid piece of silk was produced, which was presented to Her Majesty by Mrs. Whitby, of Newlands, the lady to whom I have alluded. But how did she effect this? Why, instead of cultivating the old black mulberry, she cultivated another species — the *Morus multicaulis* (Fig. 6), having a leaf and fruit somewhat of a different kind, and not so eatable as the common mulberry; and she found this species produce leaves much earlier than the *Morus nigra*,

Fig. 6.

and on this account she succeeded from year to year in producing good crops of silk of the best quality. From her experience, therefore, we may conclude that silk may be cultivated in this country; and I do, therefore, most earnestly recommend the subject to the study of those who are anxious to increase the means of employing our agricultural poor. There is no question that the time of females and children may be most profitably employed in attending silkworms, where they have nothing better to .io. In the South of Europe the silkworm is fed on the *Morus alba* (Fig. 7), but it is too delicate to bear leaves early enough for the silkworms in this country. There is one great drawback to the culture

Fig. 7.

of silkworms, and that is, the disease to which they are subject, which is called muscardine.

Those who are at all engaged in the manufacture of silk, in the sale of silk, or in the purchase of silk, well know how it has varied in price, and how much the markets of Europe have been affected by the prevalence of this disease. It has destroyed large numbers of the European worms within the last four or five years. Now, this disease is of a kind that sometimes affects the human body. The human hair is occasionally affected by a fungus, which produces disease. This fungus attacks the body of the silkworm, and so entirely destroys the creature, that when the time comes for it to form its cocoon, it is utterly unable, and the result is, a failure of the crop. Here is a drawing of a diseased worm and the fungus which attacks it. (Figs. 8, 9, 10.)

Fig. 8.

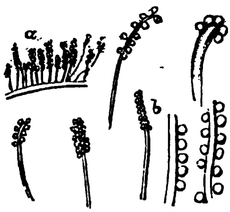


Fig. 9.

Fig. 10.

It has been lately found, in France, that feeding them with sugar prevents the disease; but it further appears that it is a disease of overcrowding, such as arises in our courts, alleys, and close streets, where we want to occupy as little ground as possible. People who cultivate silkworms crowd them together in close places, without a proper supply of pure and fresh air; and it has been ascertained that when a large supply of

fresh air has been admitted to the cases in which they have been kept, the disease has disappeared. There is no doubt that the disease will spread from establishment to establishment, which shows that the same laws which prevail in the life of man apply to the life of the lower animals.

Now, there are several sorts of silkworms; just as we find among human beings that there are small ones and large ones, black ones, brown ones, and white ones, so we find among these creatures a great variety. In France there is the *Sina* variety, which produces white silk and a small cocoon; and there is the *Syrie,* which produces a large cocoon; then there is the *Novi,* which makes the small, fine cocoon, producing a yellowish but very lustrous silk.

The *Bombyx Mori* is not found in our fields or hedges, although occasionally a few eggs may fly out of windows and get into our hedges and produce their cocoons; but there is something in our climate which will not allow them to thrive. The year 1858 was an exceedingly favourable summer for the production of these creatures in the open air, and a communication was made at the meeting of the British Association at Leeds, by a gentleman who had seen them feed and form their cocoons on a hedge in the open air. The silkworm is a native originally of China. Whilst our forefathers were naked savages, understanding nothing at all about clothing, a large proportion of the population of China were clothed in silk. There is a lesson! You see they have not been a people of progress: they are almost a stereotyped edition of the human race. There they

were 2,000 years ago, walking in silks, and there they are now, without advancing; for they have neglected the culture of natural science, whilst we, who have cultivated it, are gradually progressing. They have had no Bacon to point out the way to investigate the properties of matter, or the importance of regarding man as the minister and interpreter of the laws of nature: they pursue the business of life as an art, and know nothing of science. If you want to progress or maintain your position, you must go on increasing your knowledge of the external world. There are other countries in Europe who are now treading on your heels, and if you do not go forward, you will be left behind; in which case you may become another illustration of the want of progress of which the Chinese are so lamentable an example.

From China the culture of silk seems first to have been introduced into Hindostan, and then into Europe, in the reign of the Emperor Justinian. The silkworm is said to have been introduced into Constantinople by two Nestorian monks, who were promised a reward if they would secure the worms which produced the silk. This they did, by secreting the eggs in hollow canes. The ancient Greeks knew something of silk, and the Romans wore it as an article of luxury; but none of them knew anything of its history. Aristotle thought it must have been produced by some worm like a caterpillar, others thought it the produce of plants; and a Roman poet refers to it as secreted by flowers. In the sixth, seventh, eighth, and ninth centuries, the culture of silk in Europe was confined to the Greeks of the Lower Empire. In the thirteenth century it was

introduced into Sardinia, where it found a home. In the fifteenth century it was introduced into France. In the sixteenth century it was introduced into England, but failed as an article of trade. We find James the First, when the English ambassador went down to Scotland to congratulate him, writing to the Earl of Marr, to beg of him to lend him a pair of silken hose, so that his sovereign might not "appear as a scrub before strangers." But throughout all Europe silk was, until a very recent period, an article of excessive value. Nor had the manufacture of silk in England up to the seventeenth century been more successful than its growth. Most of you know of the revocation of the Edict of Nantes. This intolerant act, which drove half a million of people from their homes, threw on to our shores 50,000 intelligent Frenchmen, who, many thanks to them, laid the foundations of the great silk-manufactories of this country. This great branch of industry was to rise and rise, and never go back—always to increase. Although we could not rear the silkworm, we were able to manufacture the silk, and now we have a great trade in silk. In 1820 our exports were valued at £371,000; in 1856 they had reached £3,000,000. The average imports of silk in 1856, 1857, and 1858, were worth £7,000,000. We have at this moment 300 silk-manufactories, with two millions of spindles going, and steam machinery of 4,000 horse-power; independently of the hand-weaving of Spitalfields, we have 15,000 men and 35,000 women employed in the manufacture. It is supposed that all those engaged in the production, manufacture, and sale of English silks, do not number much less than a

million of persons. Some curious calculations have been made with regard to the quantity of silk manufactured in the city of Lyons. It is stated that the silk consumed in the year 1840 was 2,205,000 lbs.; and that it was produced by four thousand millions of cocoons. The fibre of one cocoon measures 1,526 feet in length; so all the silk fibre consumed in one year in Lyons, would measure six billions, five hundred thousand millions of feet; which is a quantity enough to wind fifty-two thousand times round the circumference of the earth. So much for the manufacture of one town alone; and, of course, our manufacture is much larger than that.

Now let us look at the way in which the silkworm performs its share of the work. After the creature has cast its skin five or six times, it begins to form its cocoon, which is very much shorter than itself. We may well wonder how it can do this; but if we watch it, we find that it is done by fixing the hinder part of its body, and then by raising the forepart, which is very flexible, giving facility for reaching its tail, and thus covering itself all over with the web. By this means the hardened case is formed, which we call the cocoon.

Fig. 11.

The way in which the silk for the web is formed is very curious. Let me here draw your attention to the interior of the animal, in which are two large glands, one on each side of the body of the silkworm; and it is in these glands that the material of the silk is

secreted (Fig. 12). These glands end in ducts, which terminate in an organ called a spinnaret (Fig. 13); and on each side of the spinnaret are two little glands, which produce a sticky matter, very much like the silk itself, by which the produce of the two larger glands is made to adhere together and produce one fibre. This substance, when placed under the microscope, is found to have a very simple structure (Fig. 14). It is transparent, and composed of a material called *sericin* by chemists. The silken fibre has great strength, and, perhaps, is the strongest of all organic fibres, in proportion to its size. The value of silk, then, depends mainly on its strength and fineness.

Fig. 12.

Silk is obtained by the English manufacturer from

Fig. 13.

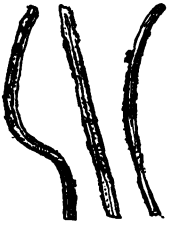


Fig. 14.

various parts of the world,—principally from France, Italy, China, and the East Indies. It is, however, produced in many other parts of the world; as Sweden,

Russia, and America. From the East Indies various kinds of silk are obtained from the wild moths I have before mentioned. The best-known of these is the tussah silk, produced from a moth in the western parts of Hindostan. The Chinese tussah silk is said to be obtained from the great atlas moth. North America produces three species of native silkmoth; the one, feeding on the willow and plum, in Louisiana; a second, living on the walnut and liquid amber, in Georgia; and a third, reared on the apple, oak, and beech, in Georgia. The silk is inferior; but it becomes an interesting question as to whether some of the worms of these moths could not be profitably reared in England.

Fig. 15.

The way in which the silk is obtained is, to feed the worms with mulberry-leaves in a suspended basket, as in this drawing. (Fig. 15.) In a few weeks the worm spins its cocoon; several of these cocoons are then taken and placed in vessels heated with water, or in an oven, in order to destroy the chrysalis. The silk is then reeled: each end of silk is placed upon a reel, and as the reel goes round, the silk is wound off, and then formed into what are called hanks. (Fig. 16.)

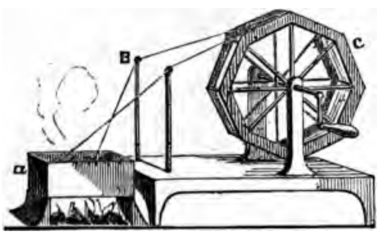


Fig. 16.

Now, the raw silk next is manufactured into what is called spun silk, and it is twisted on to wheel spindles, and then afterwards re-wound into the form of small hanks, or skeins. There are three kinds of spun silk—*singles, trams,* and *organzines,* or thrown silk. Singles consist of a single reeled thread, twisted to give it strength and firmness; tram is formed of two or more threads twisted together,—in these states it is used for forming the shoot or weft; organzine, or thrown silk, consists of two, three, or more singles being twisted together in a contrary direction to that in which the singles of which it is composed are twisted.

The next process to which the silk is submitted is dyeing. It is first scoured, to get rid of a glutinous substance called gum. If the silk, however, is not to be coloured, but is intended to be made up white, then it is not submitted to this process. We have black, blue, and red dyes, of various shades: for black, galls and iron, with indigo, are the most frequent substances used; but there is frequently a great fraud committed in dyeing silk black: the silk is made to weigh sometimes 25 per cent. more when dyed than before. This is done by adding sugar, as silk will absorb a considerable quantity of this substance, which makes it heavier and to assume a stouter appearance. You may easily ascertain the presence of sugar by the taste. The red colours are given by the agency of cochineal and of lac, which are produced by insects. Thus the cochineal and lac insects contributing their produce, with that of their brethren the silkworms, render "silken scarlet" truly an insect fabric.

It would be out of my province to deal with the

different manufactures, but I will call your attention to the great variety of them. There are plain silks and figured silks; then we have the beautiful surfaces called satins and satinettes; we have also a very peculiar form of silk which is made into shawls. We have silk lace, and large quantities of this lace are made by machinery; but the best silk lace is finished up by hand. There are hundreds of women employed in this interesting manufacture in the neighbourhood of Nottingham. Then there are damasks and brocaded silks. Poplin consists of four parts of wool and one of silk; and there are many other mixed fabrics in which silk forms a part. Nor must we forget crapes, and the infinite variety of ribbons, the product of the looms of Coventry, Derby, and other places. Now, during the manufacture of silk into these various fabrics, we have a large quantity of waste. We import into this country cocoons which have had their silk reeled off, and they are called knubs and husks, which still yield silk used for coarser goods. There are also other forms of silk waste, which are spun and woven into a variety of fabrics, so that no portion of the fibre is lost at all. Even in China, after they have used up the knubs and husks, they take the chrysalis and make the most of the delicious morsel by converting it into a stew, which is used as an article of diet.

The little glands which form the silk are remarkable for the strength of their substance, and an article is manufactured from them called silkworm gut, which makes an exceedingly strong and useful line for the hook of the angler; and those who are fond of the "gentle art" will appreciate this "silkworm gut."

Even ladies' bonnets have been made of this substance. So that you see there is hardly any part of the little creature which is not more or less useful to man.

I cannot now allude to other insect products. I have brought forward the silkworm insect as an instance of a contribution of the invertebrate tribe of animals to the materials used by man in his arts and manufactures. In the next Lecture I shall consider the subjects of wool and hair, and their importance in manufactures.

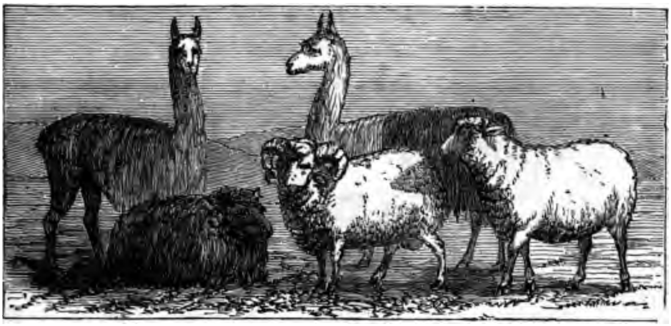


Fig. 1.

ON WOOL.

I PROPOSE in this Lecture to leave the invertebrate animals altogether, reserving shell-fish and other creatures belonging to that group for another, and now proceed to bring before you some of the products of the higher classes of animals—the vertebrate animals.

There are various ways in which we might treat this subject. We might take up the animals according to their natural-history classification, but the objection to that would be that we should have to repeat a great deal in one class of what had been said in another; so that I propose, first, to take the whole group of these animals, and speak of the various parts of the whole of those which are used in the arts and manufactures.

All animals, as well as plants, are covered with what is called an epidermis. If we take a brush and

brush our hands or arms, we shall observe a quantity of dust to fly off. If we collect this dust, and put it under the microscope, we shall find it composed of a series of scales or cells, such as are seen in this drawing (Fig. 2). Now these are called epidermal

Fig. 2.

cells, and the whole of the membrane which lies at the top of the skin is composed of these cells, of which Fig. 3 is a section. The mass of matter which you see lying above the true skin is called the epidermis. It is this part which rises when we apply a blister to the skin; the water coming from the true skin beneath, and pushing it up. This epidermis extends throughout the whole animal kingdom, and is not confined to animals but is also to be found in plants. If we look on the outside of plants, we shall find in all, except water-plants, that there is a delicate membrane lying on the surface, composed of cells which are much more dense, and firm, and closer together than

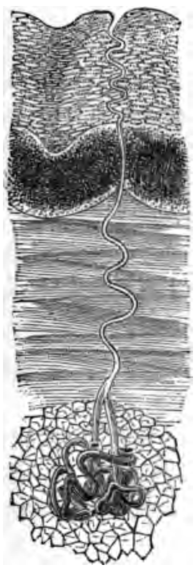


Fig. 3.
Sudoriferous Glands.

those which lie immediately under. This external membrane is called the epidermis in plants as well as in animals. In both plants and animals, appendages are found upon the epidermis. In plants they are called warts, villi, hairs, or prickles, according to their form and hardness. When the hairs have cells at their base, which secrete a poisonous matter which stings us when we touch them, we call them glands, such as the hairs of the common stinging-nettle. We find, also, that when this membrane is carried into the interior of the organs of the plant, it forms a softer set of hairs than it does when it is on the exterior; thus we find that it lines the interior of the date, the orange, and other fruits, but above all it lines the interior of the fruit of the cotton-plant. When the epidermis extends from the outside to the inside, it forms a membrane called the epithelium. In the same way as hairs grow on the epidermis, they will grow on the epithelium, and the most important article of our manufactures is this hair that grows inside the cotton fruit. These cotton hairs, as may be seen under the microscope, have a little twist given to them during their growth, a permanent bend, which enables us to twist them into a thread, and from these threads to form a fabric, the manufacture of which distinguishes us among the nations of the world. Whatever importance our manufactures possess, we owe to cotton first; and then come wool, and silk, and leather. In our manufacturing industry we use the hairs of animals, and they may be woven in the same way as the hairs of plants. I want to draw your attention to the fact that this epidermis of animals will produce hairs

just in the same way as it produces hairs in plants—not only hairs but a variety of organs which we do not recognize by the name of hairs. We should hardly call a corn on our toe a hair, and yet it is an epidermal appendage of the same character as hairs. The horn of the rhinoceros is formed of the same materials as a hair. In the invertebrate animals,—crabs, lobsters, insects, and shell-fish,—if you examine them you will find that this external membrane has become converted into a skeleton, and thus we call them epidermal skeletons. And if we pass from those lower animals to the vertebrate animals, we find them producing a variety of appendages upon their skins, the object in view being the preservation of the life of the animal. Take the fish, for instance; the most distinguishing features of the fish are its scales, which are formed in the same way as hairs—we divide fish according to the form of their scales. There are two forms of scales, which are very common among our fish of the present day; and there are forms which are common in extinct fish, and it is by these the palæontologist is able to group the species of fish. The crocodiles, the alligators, and large numbers of the saurian reptiles, are protected by epidermal scales; we even find that some of the mammalia, as the long-tailed manis and the armadillo, are clothed with scales. The feathers in birds are modifications of the same organs, and we shall find amongst the mammalia organs very much like feathers, in the quills of the porcupine and hedgehog. Then we have in the mammalia hoofs and horns, which are epidermal appendages.

The claws and bills of birds, and our own nails, are

all formed of the same materials as hair. Now, I want to call your attention to the way in which this hair is formed. In the skin there are little depressions, little holes, follicles; some have hair and others have no hair. Those follicles are filled naturally with an oily matter: but when the hair is formed, we have little blood-vessels supplying the lower part of the follicles; and the supply of the cells depending upon the quantity of blood or materials for nutrition at the bottom, we find that the cells grow faster here, and thus the hair is, as it were, pushed out. Here is a drawing of the human hair in its follicle (Fig. 4). Corns are formed in the same way, but not in a follicle; when you have a tight boot, you produce an irritation, which nourishes the epidermal appendage of which so many complain. So it is with warts: they are an excessive secretion of these epidermic cells.

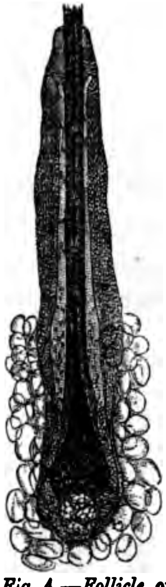


Fig. 4.—Follicle of Human Hair.

The subject I wish to bring before you now is wool, not hair; but wool is nothing more than a modification of hair. We call that wool which has a tendency to curl. We say when a man's hair curls and is crisp, that he is woolly-headed, and there are woolly-headed races of mankind. Well, that tendency, which we occasionally find in the human race, is constant in certain animals which yield the substance called wool, and we shall find that the growth of this wool is attended with alterations, by which it can be used for purposes

for which we cannot use hair. We cannot weave human hair—we cannot felt human hair—we cannot make such warm garments with hair as we can with wool. If you put a piece of human hair under the microscope, you will find that there are little markings running across it (Fig. 5); but if you take the hair and

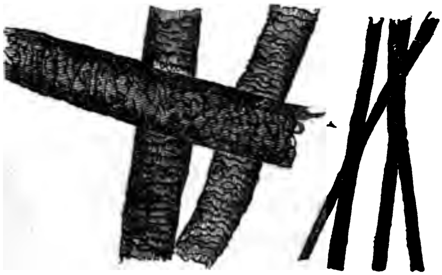


Fig. 5.—Human Hair.

boil it for a length of time, treating it with sulphuric acid, you will split it up into little cells having the character of epidermal cells. Now, if you put the wool under the microscope, you will find you have lines running across, but much more serrated than they are in the hair. Here are representations of Russian, African, and Chinese sheep's wool, and of camels' wool. Thus you see the microscope proves to us that the markings are much more prominent in wool than in what we call hair. This is dependent upon the fact that these woolly hairs possess looser scales in their structure, and this is the reason

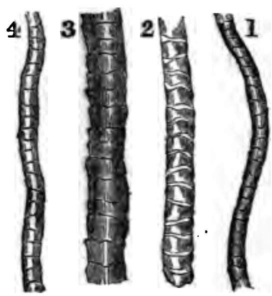


Fig. 6.
1. *Russian Wool.*
2. *Cape* ,,
3. *China* ,,
4. *Camels'* ,,

of their being so useful in the arts. The woollen manufacture depends upon the imbrications which you see in the kinds of wool.

Calculations have been made as to the number of these serratures. Mr. Goss finds that the finest Saxony wool contains 2,720 of these serratures in a single inch, which will give you some idea how much wool is magnified in our drawings. Saxony wool is used for making superfine cloth, and it is a kind of wool that we never get from English sheep. Wool with the finest serrations is used for the finest cloth. Merino wool presented to Mr. Goss 2,400 serrations (Fig. 7).

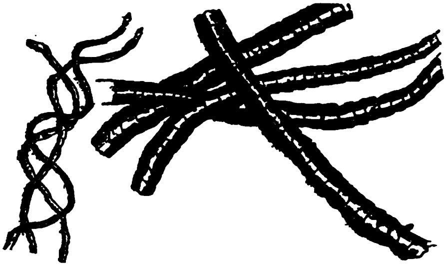


Fig. 7.—Spanish Merino.

Now we come to our own Southdown fleeces, which are known by manufacturers to be inferior to the Saxony wool; and Mr. Goss found in Southdown wool (Fig. 8) 2,080 serrations to the inch; and when we come down to

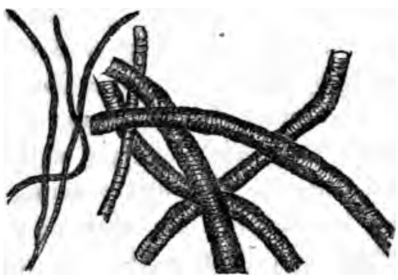


Fig. 8.—Southdown Fleece Wool.

our Leicester wool, which is still less valuable for

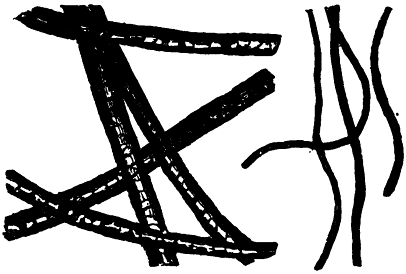


Fig. 9.—Leicestershire Fleece Wool.

cloth, we find only 1,850 of these serrations (Fig. 9).

These observations render it exceedingly probable that the manufacturer would be able to detect the quality of the wool by the use of the microscope. It is all very well for men to say, "We can use our hands and our eyes, as we have done from the time of Adam, and we do not want any of your new-fangled instruments;" but that is like a man rejecting the use of one of his eyes because his grandfather had lost an eye. By the use of the microscope, we can detect qualities in the wool hitherto unknown even to the practical man. These serratures, then, are of great importance in relation to the uses of wool; and it would appear that the process which is called felting depends entirely on these little serratures becoming entangled one in another. A piece of cloth may be felted without weaving. All cloths go through the tremendous knocking of the felting process, but many fabrics are made by the felting process alone.

You cannot too early know the distinction between the uses of wool; one set of things is converted into what we call cloth by the felting process, and another set is converted into what we call worsted or stuff, which are made from the hair which does not felt well, and it is the proportion of these serratures that deter-

mines the destination of the wool. The longer the wool, the less the number of serratures in the inch, and the shorter the wool, the greater the number of these serratures in the inch. Short wools are therefore preferred for the cloth-manufacture, and long wools for the worsted-manufacture. We have instances of the use of wool for felting, which show that the process of felting has been known almost from time immemorial. As to other hairs, nearly all *rodent* animals produce hairs that will felt; as the stoat, the mouse, the sable, the rabbit, and the hare (Figs. 10, 11, 12, 13). Here I may remind you that the beaver

Fig. 10.—*Rabbit Fur.*

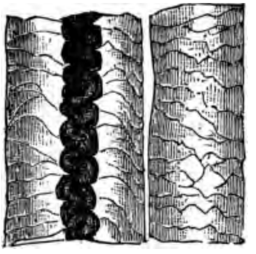


Fig. 11.—*Misquash.*

Fig. 12.—*Mouse.*

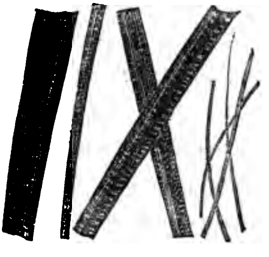


Fig. 13.—*Squirrel.*

hat, which is becoming almost as scarce in this country

as the beaver himself, is made by the process of felting (Fig. 14).

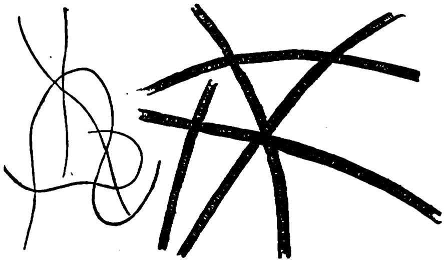


Fig. 14.—*Beaver Fur.*

In making beaver hats, the hair is mixed with cottonwool, which, although it will not felt itself, has the curious property of facilitating the felting of the beaver hat. The beaver hairs are beaten together with the cottonwool, which comes out to the surface like cream upon milk; it is then taken away, and the beaver felt is made into the hat. I have in my possession a beautiful specimen of cloth, which consists of the hairs of the rabbit, which have been woven and felted. This cloth, I should think, is likely to be useful for a variety of purposes. I have sometimes suspected, that it is not *altogether* due to these serrations—these imbrications so clearly developed in the wool of some animals, that felting is due; for in rodent hairs you always get a kind of hole or cavity in the interior, which allows the hair to yield to pressure, so that it is reduced to a third or half of its bulk by the process of felting.

I now come to the chemical nature of hair. I told you in the last Lecture that the animal kingdom was distinguishable from the vegetable kingdom by its

fabrics being generally composed of gelatin instead of cellulose; and yet that was a generalization not without great exceptions; for, in fact, hairs and silk, which I mentioned in my last Lecture, are not composed of gelatin. When we put them into boiling water, they do not dissolve, for we could not wash them in hot water if they did; but the composition is, after all, very nearly that of gelatin. There is some difficulty in ascertaining what is truly the nature of this epidermal substance, when it assumes the form of the hair, the nail, the hoof, the horn, the quill, and of the scale. These substances have been examined by the chemist, who has not, however, found anything definite in them. They contain carbon, oxygen, hydrogen, and nitrogen; but the real nature of the compound is not well understood. It seems probable, that when this matter has been used as muscle and nerve, a certain quantity passes to the skin, and there it forms the epidermal organs; but during that process it combines with a quantity of sulphur,—for all these substances contain sulphur, and that is how they are distinguished from gelatin, which does not contain this substance. This is all I can say with regard to the chemical composition; but I have no doubt the time will come when the chemist will understand of what these epidermal appendages are composed.

I come now to speak of the sources of wool. Everybody knows we get wool from the sheep. What is a sheep? Can anybody tell me the difference between a sheep and a goat? Yes, you say. Then, if you can tell in a very few words, you will confer a benefit on the naturalist. You find that the wild sheep pass

into the wild goats, and so closely resemble each other, that the naturalist is puzzled to know where one begins and the other ends. Of wild sheep, there is the *Argali,* which lives in certain portions of Asia, and is distinguishable from our sheep; and there is also the *Argali* of America—the sheep which is called *Ovis montana*; then there is a sheep which inhabits the islands of Greece. It is very certain that the old sheep which we read of in the Bible was not a descendant of the American *Argali* in any way. Then the question is, whether it is descended from the *Argali* of Asia, or the *Musimon* of Crete and Greece. There is considerable difficulty in getting at the origin of our domestic animals, and so we speak of our domestic sheep as an independent species, the *Ovis Aries.* Now, the great distinguishing features of our sheep have been maintained through a long period of time; the sheep we have at present seem to be identical with the sheep of old. The sheep of Judæa seem not to have differed from the sheep of the present day. When we read in the Bible of the tending of sheep, and their management, we feel that the sheep of that day were like the sheep of the present day—their habits were the same, their domestication was the same, and their uses were the same; for we find the man of that time eating the mutton and using the skins for clothing, until he learned to weave the wool into cloth garments.

We have what are called breeds of sheep, and those breeds of sheep are somewhat difficult for persons not acquainted with agriculture to determine. We may divide them into the old mountain sheep, the early inhabitants of our island, and those sheep more

recently reared, which are sheep of the plains. We all know the little Welsh sheep, having a leg not weighing more than two or three pounds, scarcely enough for a strong man's dinner, and they have so small a crop of wool that it is hardly worth while shearing them, and they are going out of fashion. There are, however, people from Wales who like Welsh sheep, as the Scotch like Scotch sheep; and thus the breed is kept up. But there would have been no Leeds and no Bradford, if there had been none other than Welsh sheep. Then, we have the Southdown. There is the black-faced Scotch sheep, which is also an excellent bearer of wool, and the Cheviot. Little sheep generally bear small fleeces, the Welsh and Irish generally not more than 2 lbs.; and the Leicester as much as 8 lbs., and in America a sheep has been reared that produced a fleece of 18 lbs.; so that you see that the tendency in this country has been to get a large amount of wool. At the same time, we do not produce in England the finest kind of wool. The long-woolled sheep yield a valuable produce; but it is the short-woolled sheep which produce the most valuable. The sheep of Germany, of America, and more especially of Australia, all produce better wool than English sheep. These forms are represented by the Spanish sheep. The Merino sheep, originally reared in Spain, produces the finest quality of wool for the manufacturer (Fig. 15). This wool is short, covered with a sticky secretion; but we can easily see that this wool makes the finest quality of

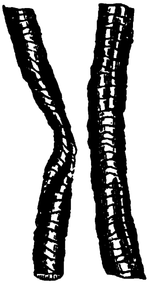


Fig. 15.—Finest Spanish Wool.

cloth that is worn. Hence it was, that many years ago attempts were made to introduce the breed of Merino sheep into England. It succeeded to a certain extent, but our climate was too damp and too cold to develop the wool of these sheep, and I believe there is not a single flock of Merino sheep in this country now, although thousands of pounds have been spent in the attempt to domesticate them. Our manufacturers can now obtain their Merino wool from Spain, but at one time the law forbade the importation and exportation of wool, and we were then confined to the produce of our own soil. It was at that time that the sheep were introduced. Spain has lost much of her prestige and much of her commerce lately, and when one hears of the climate of Spain and the vast resources of that country, one grieves to think that she is doing so little among the nations of Europe. But what has not been done by Spaniards has been done by Englishmen. A few of these Merino sheep found their way to Botany Bay. I do not mean to say that any cunning sheep-stealer carried away a flock of those sheep while he was paying the penalty of his malversations; but at any rate they were sent there, and were afterwards neglected; but in spite of that they flourished and increased, and from that small beginning has commenced an enormous development of sheep-farming in Australia; and now our largest supply of best wools is from Australia. So that you see, after all, Providence has directed the sheep in the way of the Englishman, who has turned it to his advantage.

We get other kinds of wool. I may mention the Saxony wool, which is perhaps the best spinning wool

in the world, and furnishes the fine Saxony cloths. We obtain, also, a considerable quantity of fine wool from America, and America is carrying on a woollen-manufacture from the production of its own sheep.

It would seem almost hopeless for the English farmer, while he seeks to produce fine mutton, to compete with America, Germany, and Australia, in the production of wool; but, at the same time, the mixture of breeds has presented us with wool of a greatly-improved kind, and the day may come when, at the same time that we have the best mutton on our tables, we may produce the finest wool for our cloths.

Wools are brought into this country from China, the East Indies (Fig. 16), and other parts of the world.

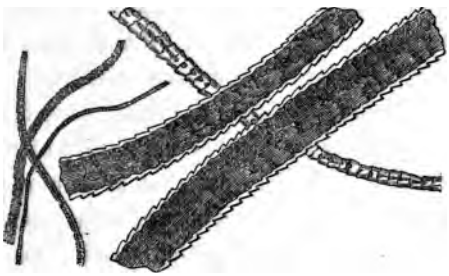


Fig. 16.—*East-India Wool.*

Other animals yield wool as well as the sheep. The camel yields a wool which is occasionally woven. It is woven by the women of Persia into a kind of coarse garment very generally worn in certain districts. Other creatures which come more actually into competition with the sheep, are the goat, the llama, the alpaca, the vicugna, and the guanaco. The common goat does not possess anything like the quantity of wool that the sheep does, but in certain parts of the world the goat produces

very fine wool (Fig. 17), which has been manufactured into the most costly garments. It yields a fleece of from 1½ to 4 lbs. of fine fleecy long hair. In 1848, it was first brought into the markets of Europe under the

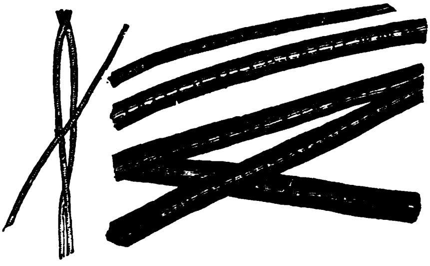


Fig. 17.—Mohair.

name of mohair. What we call velveteens and plushes are mixtures of cotton and wool; and sometimes silk and wool are mixed, and the wool of the Angora goat is particularly well adapted for these mixtures. There is a goat in Cashmere which yields an exceedingly fine wool. We know very little of the nature of this wool, but this goat yields the wool that is employed in the manufacture of the costly and beautiful Cashmere shawls. This goat yields a fleece, of which about 30 ounces are capable of being manufactured into a shawl a yard and a half square, and the worth of the 30 ounces is 8*s.* or 9*s.* Then why do these shawls cost sometimes hundreds of pounds? In answer to that question, I will read a passage from the Catalogue of this Museum:—

"Thirty ounces, valued at eight or nine shillings, is all that is required in the manufacture of a shawl a yard and a half square. The immense cost of these shawls in the European market is, therefore, a subject of much wonder to those unacquainted with the history of their manufacture and transportation. A heavy duty is first paid upon the wool; then a further tax upon the yarn when it reaches the bazaar; and the manufactured shawl, when taken to

the custom-house, is further taxed according to the discretion or caprice of the collector. If intended for the European market, the shawls have yet to pass through the ordeal of still heavier exactions. They must be borne from Cashmere across the Indus to Peshawur, on the frontier of Afghanistan, a journey of twenty days, upon the back of a man; the road being often impassable by camels or mules; deep precipices being crossed upon suspension-bridges of rope, and perpendicular rocks climbed by means of wooden ladders. At various stages of this journey taxes are exacted, amounting to 36*s*. or 42*s*. in the aggregate. From Peshawur, to near the confines of Europe, tribute is paid at many custom-houses, and the forbearance of the marauders of Afghanistan and Persia, and of the Turkomanic hordes, must also be purchased at a high price. The precious burden is thus conveyed to Europe over the Caucasus, and through Russia, or, as is now frequent, through the Turkish provinces to Constantinople."

You see, our friends in Cashmere are not aware of how fully we have discussed the question of free-trade, and determined that it is for the better extension of trade. You need not wonder, then, that those beautiful shawls, manufactured from this hair of the Cashmere goat, should sometimes reach such a wonderful price before they pass the rocky portals of the Valley of Cashmere.*

But I now pass to a family of animals that has recently yielded a large increase to our cloth-manufacture. I allude to the alpaca tribe or family, allied to the camels and dromedaries. When Pizarro conquered Peru, he found these animals employed as beasts of burden, and their wool used for making clothing. The Peruvian government has placed an embargo upon the exportation of these creatures, so that we have only now and then seen them as

* The influence of the Scinde Railway in opening up the trade of Cashmere has been very remarkable. The following statement is taken from the report of the directors of the Scinde Railway Company: In 1856-7 there were exported Cashmere shawls to the value of 25,000 rupees; in 1857-8, 534,000 rupees; and in 1858-9, 964,000.

curiosities in the collection of our Zoological Gardens; but in 1846, it appears, some of this wool found its way to Bradford.

For the successful manufacture of this wool we are indebted to the energy and enterprise of Mr. Titus Salt, who, in the application of this material to the making of cloth, has succeeded in laying the foundation of one of the largest manufacturing establishments in this country, and has conferred a blessing upon his own country, as well as the countries in which the animal is reared.

The length of the hair (Fig. 18) of the alpaca renders it of considerable value for mixing with goat's

Fig. 18.—*Alpaca.*

wool, silk, and other materials. There are four forms of these animals, very distinct from each other,—the Llama, the Alpaca, the Vicugna, and the Guanaco. The vicugna yields very fine hair, which is very much valued; but the alpaca yields the most useful hair.

I have mentioned the advantage of acclimatizing other animals. There would be no difficulty apparently in acclimatizing these animals in Australia, though, where they have been tried in this country, the rot has seized them, because of the tenderness of their feet. A few

months ago, several alpacas were secured, in spite of the jealousy of the Peruvian government, somehow or another, and sent over to Australia, where they have arrived; and I understand that a first crop of wool has been secured, and that the flock is flourishing. Such experiments as these should be more extensively and systematically carried on both in our own country and in our colonies.

I will now direct your attention to the manufacture of wool. The wool has first to be got from the back of the animal. Like all these other epidermal appendages, it is liable to be cast off. There is one peculiarity of this process, that if creatures do not throw off their epidermis by what we call a moult, it is constantly dropping away. We are continually moulting; but occasionally large quantities of hair come off at a time, and this also is moulting; at the same time, this process is a perfectly natural one. You see the process in the antlers of some creatures, and the horns of others—in the hair of all the mammalia, and the feathers of birds, and in the scales of fishes. Thus wool would fall off, but man comes in and prevents the falling and the trouble of picking it up, by shearing. Before shearing, the wool is washed. If you look at the fleeces in the Museum, South Kensington, you will see it is always stated that they were washed on such a date. This washing is necessary to make them available for the manufacture. At the base of the hairs, a compound is formed of oil and potash, which is a kind of natural soap, for carrying away the impurities of the hair, and the grazier takes advantage of this soap. Sometimes he uses various lyes, and the addition of substances for

killing insects, in this process of washing; but generally these additions are bad, and the only thing necessary is to take the animal and wash it in soap and water, and afterwards in clear water. The shearing takes place in the summer of the year. Everybody has seen the lambs staring at their mothers, on account of their altered appearance after shearing, and not being able to recognize them till their well-known bleat reassures them.

The next process is that of assorting or stapling. The wool obtained is not all long or short. Even short-woolled sheep have some long wool, and long-woolled sheep have some short wool. When the fleece is cut off the back of the animal, it is divided into wool of various qualities. Take as an example, a Southdown fleece; and I present you with the results of stapling such a fleece. You have—

1. Super wool, 1 oz. This is made into flannels, blankets, lists, tweeds, and coarse cloths.

Then we have,

2. Livery wool, 1 oz. Used for low cloths, as prison, army, navy, and workhouse cloths.
3. Grey wool, 2½ oz. Used for army, navy, prison, and workhouse cloths.

So that there is not much difference between 2 and 3, except that 2, perhaps, makes officers' clothes.

Then there is,

4. Prime white wool, 5½ oz. Which is made into cloth of all sorts; blankets, best flannels, tweeds, shawls, coburgs, and lists.
5. Choice wool, 2 oz. Used for flannels, cloths, blankets, tweeds, shawls.

Then there is,

6. Picked tegg, 1 lb. 7 oz. Used for tweeds, shawls, and blankets.

I do not know what picked tegg is. Then there is,

7. Super tegg, 6¼ oz. Employed for fringes, hosiery, yarns, and coach lace.

Then there is, finally, a long wool, of which there is about 3 lb. 8 oz. for yarns, fringes, shawls blankets, &c.

This process of stapling is a very interesting one. The persons who do it are called wool-staplers. They place the fleece on a table, and with their hands they sort out the different qualities; and it depends upon the object of the seller as to how it shall be stapled.

The wool having been stapled, it is next taken to the manufacturer. It is there scoured or washed. It contains a good deal of dirt of various kinds; it also contains grease, lye, and other animal matter, and it is exposed to substances giving off ammonia, which combines with the oily matter; and, after being thus scoured, it is submitted to pressure, in order to dry it.

When wool is to be made into black cloth, it is dyed at this stage of the process. When the manufacturer wishes to dye the cloth with lighter and brighter colours, it is dyed in the cloth. After it has been dyed, it is submitted to a process called "willying," which consists in arranging the wool in such a way that the fibres are laid parallel to some extent, and after this is done, a further process is employed of purifying, called "picking." Then comes the process of "scribbling," which is antecedent to "carding;" and this process seems to be almost as important as the felting, for it is

this carding which breaks up the wool into small pieces. In this state it has a greater tendency to curl: if you look at a piece of felted cloth under the microscope, you will see that the pieces of wool are curled (Fig. 19); and you cannot get the curl out of them. It is on this account that the carding which breaks it up is so important.

Fig. 19.—Fibre from a cloth coat.

After carding, the thread is made more dense by the process of "slubbing." Then the "spinning" takes place, and after that the "weaving." After weaving, the cloth is submitted to another process of "scouring," for they have added oil to it during the process of spinning, and they also cause the thread to pass through size, so that the threads may lie close together: so they add potash to get rid of the oil, and soap and water to get rid of the size. Then comes the most distinguishing process of the whole, and that is the "fulling." The fulling is effected by enormous wooden hammers, which are allowed to drop on to the cloth, and give it such a hammering, as no one would like to submit to, unless he were a champion of the prize-ring. By thus hammering the cloth, it contracts to a considerable extent, and is brought to a condition in which its strength is fully developed; whilst unfulled, it is weak, and easily torn, but now its filaments are bound more closely together and are not easily torn. After it has been fulled, it is again scoured, and then it is submitted to a process called "teazling,"—a process of brushing or raising. It consists in applying the ripened head or fruit

of the common teazle (*Dipsacus fullonum*) to the cloth. The teazles are attached to a cylinder, which revolves upon the cloth, and the loose particles are raised, so that they may be easily sheared or cut off, to give the cloth the fine appearance it assumes. Man has invented no instrument which will take the place of the teazle (Fig. 20). It is remarkable for pro-

Fig. 20.—*Fuller's Teazle during growth.*

ducing at the end of the little leaves at the base of its flowers, called bracts, a spine which curves downwards, and thus acts as a kind of hook brush for pulling up the loose particles of cloth. Various substitutes have been tried,—pieces of wire have been fixed into a leather back, but without the desired effect. The

teazle is imported in large quantities from France and other parts of Europe. It is, however, extensively grown in England; but the English teazle is inferior to the foreign one. After the shearing and cropping have been gone through, then come the pressing, rolling, doubling up, packing, and sending to all parts of the world for use.

Before concluding, I must add a few words about worsted. Worsted differs from wool in the fact, that you use the hair not for the purpose of felting or carding, for they neither card nor felt in the worsted manufacture, but for the purpose of weaving. In fact, wool in the worsted manufacture is treated very much as cotton. The first process consists in abolishing those serratures of the wool which are of so much use in making cloth. The longest wools are selected, and these are smoothed down by means of oil and an iron comb, which is heated: this is called combing (Figs. 21 and 22). The prepared wool is then submitted to the pro-

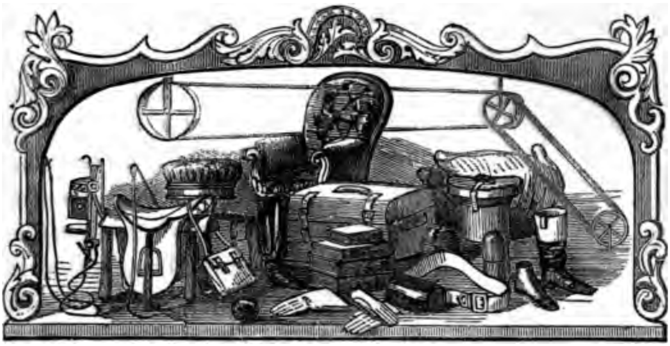
Fig. 21.
Wool ready for combing.

Fig. 22.
Wool for Worsted.

cesses of spinning and weaving, according to the purpose for which it is to be employed.

The woollen manufacture, then, consists of broad cloths, narrow cloths, carpets, blankets, flannels, serges, and tartans; whilst the worsted manufacture produces stuffs, bombazines, camlets, and shawls; and various mixed goods, as damasks, plushes, and velvets. The woollen produces a warm and heavy garment, while the worsted produces a light and loose, as well as warm garment.

Thus, you see the value of the culture of the animals around us. In course of time we may find, if we learn our lesson rightly, that there is nothing created in vain, and that whatever God has made, He has intended for the use and benefit of man.



ON LEATHER.

In pursuance of the course which I have commenced, I shall now speak of the skin of animals. In my last Lecture I drew your attention to that product of the skin which we call wool, and its various applications in the arts. I alluded to the fact that wool was one of the epidermal appendages, as they are called, of animals. I now pass over the use of other forms of hair, as horsehair, human hair, feathers, quills, hoofs, and horns, all of which are epidermal appendages. I shall come to them again, I hope, by-and-by, and be able to treat of them in a separate Lecture; but now we will talk of the skin, the substance out of which the epidermal appendages grow. I drew your attention to the epidermis in the last Lecture, and stated that the skin was composed of two parts,—the epidermis and the dermis

(Figs. 1 and 2). The epidermis is a membrane composed

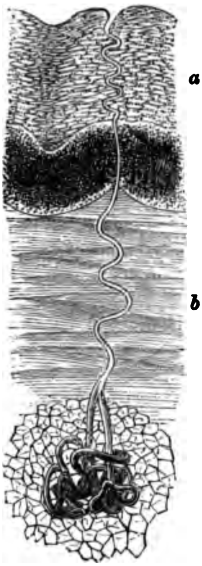


Fig. 1.—*Epidermis and Dermis, showing the SudoriferousGland.*
a. Epidermis.
b. Dermis.

of several layers of cells on the external surface of the dermis, or true skin. If we scrape the skin, we separate a substance, which if we examine under the microscope, we find to be composed of a number of flat cells (Fig. 3); and if we examine deeper, we shall find that some of the cells are spherical; so that this outer portion is entirely composed of cells. This, then, is the epidermis or scarf-skin. The epidermis is continued in the animal — into the mouth, into the organs of respiration, and the interior organs, where it is called mucous membrane; and we find this mucous membrane is covered with scales, which are called epithelium. I only want to show you here that the skin is continuous with the mucous membrane; and you may

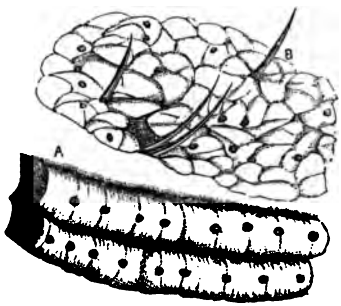


Fig. 2.—*Epidermis—Surface View.*
A. *Palm of Hand.* B. *Back of Hand.*

regard an animal as a sort of bag. When the internal organs are formed, the skin is as it were tucked in. But we have nothing to do now with the internal organs or membranes, which are, however, used in the arts. I have to call your attention to the skin itself.

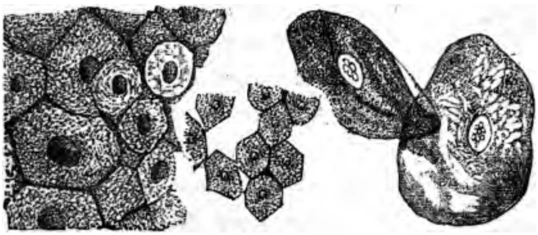


Fig. 3.—Cells of Epidermis.

There is one point, with regard to the epidermis, which I want to allude to before I leave it. The epidermis gives the colour to the animal; and not only does the epidermis give the colour to the lower animals, but it also gives colour to man. You know that there are some races whom we are fond of calling the "less-favoured races of mankind," which are black. Sprinkled among the epidermal cells you will find a quantity of polygonal cells, which are called pigment-cells, which give a dark colour to the skin. When these pigment-cells are absent, we call such persons albinos, and when those cells are abundant, we call such persons "blacks;" and in proportion to the number of these cells is the colour of the individual or the races of mankind. The origin of these cells is a very interesting question, and one not easily decided; but there is reason to believe that the original colour of mankind was black, and we have certainly no more reason to con-

clude that Adam was white than that he was black. There is no evidence of the one being the true theory any more than the other. These cells are found in that portion of the epidermis which forms the hair, and their presence or absence constitutes dark or light hair (Fig. 4).


Fig. 4.—Follicle of Hair.

It is the same in the lower animals: the black animals have these pigment-cells in their hair, whilst the white animals are without them. Again, these cells are so constructed as to reflect a variety of colours; and thus we have the various colours of animals, produced by the abundance or absence of these pigment-cells.

Passing from the epidermis, I come to the layer which lies below it. It is of importance to those who work on the skin to understand its structure. It is to a knowledge of the nature of the skin that much of the recent improvement in the process of tanning is due. The under layer of skin is called the dermis. It is that layer which lies under the part which rises when you put a blister on the skin. Now this is composed of a basement membrane, in which there are blood-vessels. The cells which compose the epidermis are produced by the agency of the blood-vessels, which consist of arteries which run in one direction, and veins running out in the other; so that this thick part of the skin is copiously supplied with blood-vessels. That these blood-vessels are *present,* we can see in the leather after it is tanned, as

in this drawing (Fig. 5). This fibrous condition arises from these vessels.

Fig. 5.—Blood-vessels of Dermis.
A. *Palm of Hand.* B. *Back of Hand.*

Then we have in the skin, which is the organ of touch, nerves running from the spinal cord. These nerves run up into little organs, called papillæ (Fig. 6).

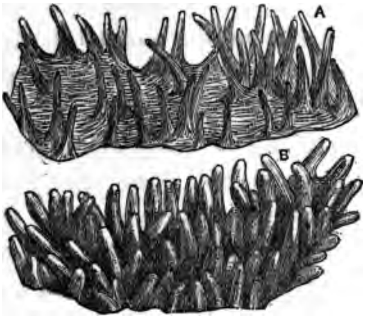


Fig. 6.—Papillæ of Skin.
A. *Palm of Hand.* B. *Back of Hand.*

They receive the nerves, which pass up through the dermis into the epidermis. These organs give the power of receiving impressions from outward objects by touch.

In addition to these organs, we have in the skin a number of glands. There is first a set called sebaceous glands or follicles. These little glands are intended to secrete a quantity of unctuous matter, which is constantly accumulating upon the skin, and which keeps the skin soft and pliable; and it is these little glands which frequently get blocked up, and form little black pimples on the face. They are frequently found accompanying the hair-follicle, as in Fig. 7. Sometimes these little follicles are the seat of an insect, called *Demodex folliculorum* (Fig. 8), and these are often found in the side of the nose. They may be squeezed out, and if placed under the microscope, are seen to be highly organized. They are not indications of disease, but their presence shows that these creatures have found the proper locality in which to exist, and they form a very interesting study to the naturalist.

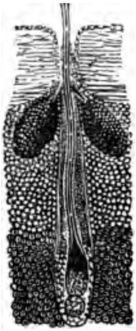


Fig. 7. Sebaceous Gland, on each side a hair-follicle.

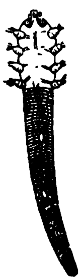


Fig. 8.--Demodex folliculorum.

It is the perspiratory glands to which I would call your attention more particularly. Here you have a drawing of these glands (Fig. 9); and you see they consist of a little tube, which runs into a gland, which is well supplied with blood-vessels, and is seated in the thicker part of the skin. The great function of these glands is to draw water from the blood, and they open by little pores on the surface of the skin; and if you look at any portion of the skin, the top of the thumb

for instance, with a common magnifying-glass, you will see that there are a series of elevated ridges and little pores, which are the terminations of these perspiratory ducts. Curious calculations have been made as to the number of these ducts (Fig. 2, B). Mr. Wilson states that there are 3,528 of these pores in a single inch of the skin;

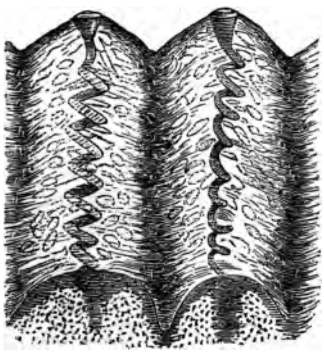


Fig. 9.—Epidermis, greatly magnified, showing the Perspiratory Glands.

so that in an ordinary-sized body there are not less than 2,300,000 of these pores; and the tubes have a certain length; and it is calculated that there are in the human body not less than 28 miles of this tubing. Now, the great function of these glands is to keep the heat of the body at a fixed temperature,—98 degrees. If it were not for that, our bodies would get up to a higher temperature than 98 degrees.

Thus you see that the skin is a very complicated organ. The chemical substance of which it is composed is principally the compound called gelatine, of which I have spoken before; and this gelatine can easily be procured from all parts of animals. We obtain it from the refuse of various manufacturing processes;

thus, it is procured from the clippings of hides, the refuse of bones, and other animal remains. I only mention this now to show you that the skin is principally composed of this substance called gelatine. This substance appears to be formed from the food, or, rather, from that portion of the tissues of our body which are sometimes called proteinaceous. If we take any portion of the living tissues of an animal, such as the nerve or muscle, we have fibrine in the muscle, and albumen in the nerve: albumen and fibrine are forms of protein. Mülder says, protein is composed of the elements nitrogen, hydrogen, oxygen, and carbon,—the four organic elements; and without entering further into the chemistry of this matter, I will just say, that the impression is, that gelatine is formed out of this fibrine and albumen after they have served the purposes of life in the muscles and nerves; it is then used for less-important purposes, such as making the walls of the cells, the skin, and other parts of the body; in this state it is about to pass away altogether from the body. In the next change, we find its elements in some of those acids and substances in the blood which are about to be thrown out. The fact of gelatine being present in the skin, constitutes the foundation of the art of making leather. There could be no tanning if it was not for the presence of gelatine. Gelatine is remarkable for being insoluble in cold water, but soluble in hot water; so that we may take any of these skins, and put them into cold water for any time, and they will not dissolve; but we can take the clippings of skins and dissolve them by heat; so that when we evaporate the water, we have the

gelatine left behind. Gelatine is used for making size, for making glue, and for a variety of purposes; it is also used as an article of diet. Even coarse bits of leather can be taken and boiled down, and made into gelatine, and then into jellies. Gelatine exists in the sound of the sturgeon and some other kinds of fish, and is procured under the name of isinglass, which we use for jellies. One remarkable feature of gelatine is, that when it comes in contact with a substance which is known by the name of tannic acid, it forms an insoluble precipitate. And here is a very remarkable thing worth a moment's thought, that two soluble substances meeting together should form an insoluble substance. If we take some tannic acid and add it to a solution of gelatine, we get a precipitate; this precipitate is called *tanno-gelatine*, and is of the same nature as the substance formed by immersing a piece of skin in tannic acid. It is due, then, to the presence of gelatine in the skin, that the manufacture of leather, by means of tannic acid, is carried on. But before speaking of tannic acid, I would just say this, that although, when we boil skins and other parts, and get gelatine, which we separate, yet there is no proof that this is the identical substance which is contained in the skin or in the animal substance before it is boiled; it is perhaps wrong, therefore, to say that leather is merely tannic acid and gelatine, because we do not boil the skin and convert it into gelatine before it is made into leather. Then, what are these tissues composed of? Why, they are composed of a *gelatigenous substance*, which, if you put it into hot water, forms gelatine. Then, what is

it? You must put the question to a more profound physiologist and chemist than I am. The question is, I believe, still an open one to determine what this substance is. We do not yet know everything about leather, and what I want to show you is, that however much the chemist may know, there is still a great deal more to learn; and that whatever encouragement chemists have met with, there is still a great deal left to clear up and to study, by which the intelligent workman may advance his own interest, and add to the welfare of the community. It is not, then, to be taken as a settled question that gelatine is the substance which we convert into leather, in the same way that the tannic acid and the gelatine, mixed together, produce an insoluble substance.

Our next question must be, what is tannic acid? Tannic acid is a substance that has been discovered to be present in the barks of all those trees and in all vegetable matters which have been employed by the tanner in converting skins into leather. This substance, when first discovered, was called *tannin*. It is, however, now found that it is not a neutral substance, but that it is capable of combining with the oxides of the metals as an acid, and it is called tannic acid. The chemical equivalents of this compound are carbon 28, hydrogen 9, oxygen 17. Those who recollect the chemistry of plants, will see how easily vegetable tissue of any kind may be changed into tannic acid. Wood is composed of carbon 12, hydrogen 8, oxygen 8; and you see how little change is necessary to convert cellulose into tannic acid. Double the carbon, leave the hydrogen very near as it

is, and add a little more oxygen, and the change is complete. Then, if you take the food of plants, which is chiefly water and carbonic acid gas, in them you have carbon, oxygen, and hydrogen. If you take 28 parts of carbon, and the quantities of oxygen and hydrogen which you find in carbonic acid and water, and take away the excess of oxygen and hydrogen as necessary to other functions of the plant, you get tannic acid. Now, there is another acid which is constantly formed with it, and this is gallic acid. Gallic acid is called so from the nut-galls, in which it is found in largest quantities. There is a great variety of these galls: they are always found on plants containing tannic acid. If you add three proportions of hydrogen and three proportions of oxgen—that is, three proportions of water—to the tannic acid, you get the real proportions of gallic acid. Thus we find that tannic acid is easily convertible into gallic acid, at least on paper.

Why I mention this gallic acid is, that it will not tan — it will not form an insoluble precipitate with gelatine—it will not combine with the hide at all. So you see, if tannic acid can be converted into gallic acid by the action of water, it is a matter for thought and inquiry to the tanner—to prevent the loss of tannic acid and to avoid the production of gallic acid. There are certain conditions in which tannic acid will rapidly run into gallic acid—by free exposure of tannic acid to the air, it forms gallic acid, and by taking the old tanning material, and adding to it tannic acid, you find that this used-up substance will actually start the series of changes by which tannic acid is converted into gallic acid. There are in fact several processes and several

circumstances under which tannic acid, which is so useful to the leather-maker, becomes converted into gallic acid, which is of no use at all. The only use of gallic acid that has been suggested in the process of tanning, is that it may soften the skin. Sometimes the skin is put into sulphuric acid to soften it. Now, the gallic acid may act as the sulphuric acid does, by opening, as it were, the pores of the skin, and allowing the tannic acid to come in. It is, however, a fact that leather which is produced by means of tanning substances which do not form gallic acid, is not liked by the shoemaker, or by those who buy leather directly from the tanner. Those who are familiar with leather know that there is on the outside of it what is called "bloom," which is a peculiarity of the surface of the leather; it is like the bloom upon the peach or the plum. This bloom on the leather can be rubbed off with the fingers, and the leather-buyer always prefers leather with the bloom on. It would appear that unless a certain quantity of tannic acid is converted into gallic acid, you get no bloom; and therefore the tanner is obliged to use a certain portion of gallic acid, in order to supply his customers with this bloom, as a matter of taste.

Before speaking of the sources of tannic and gallic acid, I would call your attention to the fact of their forming black compounds with the salts of iron. Leather itself may be made to turn black upon the application of iron. If we add a solution of iron to tannic or gallic acid, it turns black. These compounds are used for dyeing cloth and other materials black, and nut-galls are used for the purpose of producing our common black writing-ink.

The plants which yield tannic acid are very numerous; and just as chemistry has made inquiry into the nature of materials employed in the arts, have we found the substances which contribute tannic acid become more numerous. The tanner of old used oak-bark. The bark of the old English oak (*Quercus Robur*) was the source of the tannic acid, which has been employed from time immemorial, and to the present day it is the oak-tree which yields us the largest quantity of bark. The consumption of oak-bark in this country is between 200,000 and 300,000 tons in a year; while there is not more than 5,000 tons imported from other countries. The bark is cut in the spring of the year. Young trees, twelve years old, are those which are preferred by the tanner. It is said, in fact, that the older a tree becomes after twelve years, the less tannic acid the bark will yield; so that trees twelve years old are the best trees for the tanner. It is stated that in mild springs the tannic acid is very much larger than in wet and cold springs. It is also stated that the yield of the tannic acid is very much larger if the bark is obtained during the time that the spring sap is ascending. Sometimes the tree is cut down, and I think it is the most humane way: for of all the melancholy sights which can be presented to one's eye in the country, there is scarcely any more pitiful than the ghost of the stripped oak-tree standing bleached and bare. The giant of the forest, thus exposed, soon dies; for trees cannot live without their bark. Besides oak-bark, two sorts of acorns are used in tanning,—the one called *valonia*, the other *camata*. Valonia, which is the largest, is the produce of the oak of the Levant (*Quercus*

Ægilops — Fig. 10). These acorns contain a very

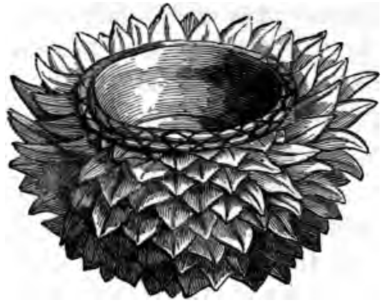


Fig. 10.—*Valonia.*

considerable quantity of tannic acid, and are more effective, weight for weight, than the oak-bark itself. Sir Humphry Davy calculated that four pounds of oak-bark ought to make one pound of leather; whilst two pounds of valonia will produce one pound of leather. The *camata* are smaller acorns. They are imported from Smyrna, and seem to be the produce of younger oaks of the same species. There is another substance which is used in making finer leathers, and this is the produce of a plant sometimes found in this country, but growing abundantly in the south of Europe, and known by the name of Sumach. There are two kinds; one the *Rhus coriaria*, used for tanning, and the other the *Rhus cotinus*, for dyeing (Fig. 11).

Fig. 11.—*Sumach.*

Sumach-bark generally contains from 16 to 20 per cent. of tannin; so that sumach is a better tanning substance than oak-bark. It is, however, more expensive, and there are certain drawbacks to its use. Unless leather has a certain light colour, it is not marketable, and leather-purchasers will not buy leather of a dark colour. The leather-maker is therefore hampered by this condition, and this has been the drawback upon the use of numerous tanning materials, and amongst others of this sumach.

Fig. 12.—*Divi Divi.*

Another tanning material are the seeds of a leguminous plant (*Cæsalpinia*) like peas and beans, which are known in the market by the name of Divi Divi (Fig. 12). They are not so much employed as other things, because they contain large quantities of gallic acid. Then there are the fruits of a tree (*Terminalia*) looking like elongated plums, and these are called Myrobalans (Fig. 13); they contain a good deal of gallic acid as well as tannic acid, and can be employed by the dyer as well as the tanner, but still have the drawback of colouring the leather. Then there is a substance called Catechu, Cutch, or Terra Japonica, because, when first known, it was supposed to be an earth. It was used only as a medicine; but subsequently it has been found to contain 50 per

Fig. 13.
Myrobalans.

cent. of tannin. When it was found that tannin was the substance which formed leather, this substance, which had been used for two hundred years in medicine, was found to contain tannin, and now it is brought in very large quantities into this country. It is the produce of a tree growing in the East Indies called *Acacia Catechu.* The natives cut down the trees and cut them up into logs, and boil them, and evaporate the liquor by exposing it first to heat and then to the action of the sun to finish the evaporation. The latter part of this operation is principally superintended by women. The extract thus prepared, consists of 40 to 60 per cent. of tannic acid. Numerous varieties are brought to this country from various parts of the world besides the East Indies.

Mungo Park, during his travels, discovered an exudation from the trees (*Pterocarpus erinaceus*) of some parts of Africa, which he thought was a kind of dragon's-blood; but this substance, which is now called *kino,* is found to contain 70 per cent. of tannic acid. When tannic acid exudes from trees, it is now brought into the market under the name of kino.

A tree is used for tanning in the United States known as the hemlock spruce (*Abies canadensis*). It belongs to the pine tribe of plants, and is an excellent substitute for our oak-bark; but I fancy it colours the leather. The larch, another plant of the pine tribe, grows abundantly in Scotland, and is used in tanning; but the leather is a second-rate leather. I may here remark, that it is always worth the while of a manufacturer to make a second-rate article, provided he does not obtain by deception a first-rate price.

Willow-bark, ash-bark, and the bark of many other British forest trees, contain tannic acid, and have been employed for converting hides into leather. There is a bark brought from Australia, the mimosa or wattle bark (*Acacia*), which also contains tannic acid. These are very important facts for people to know in this country; for you know that we are none of us going to live the whole of our lives in England. We all contemplate one day emigrating, if the Reform Bill is not passed, or the paper duties repealed, or something else not done as we like, we make up our minds to emigrate; and large numbers of us do emigrate; and therefore it is of the very greatest consequence that we should take with us a knowledge of the arts and sciences, and the great principles on which our manufactures are founded, to our colonies. If we had done so at first, we should have earlier found gold and copper in Australia, and gutta percha in Hindostan; and many more colonial manufactures would have been established, and the trade products of our colonies would be much more numerous than they are now. Then, I say, let us educate our boys now, so that when they go out and see a thing likely to be useful, they may not pass by it as if they possessed no more sense or intelligence than the wild animals of the region. By the diffusion of a knowledge of such facts as these amongst our population, we shall contribute alike to the welfare of the colonist and the wealth of the mother country.

Many plants contain tannic acid that we should not think of using for the purpose of tanning leather. There

is the tea-plant. A quarter of all the tea we use is tannic acid; every pound of tea contains a quarter of a pound of tannic acid, although there is no fear of its turning the mucous membrane into leather; for whilst it is alive, the stomach will not submit to the process of tanning; yet tea is often a great offender of the stomach by reason of its tannic acid. I may mention that there are persons in India who chew catechu; and here is the betel-nut palm (Fig. 14), which yields the nuts

Fig. 14.—*Areca Catechu.*

containing tannic acid, which are cut up and chewed with a little lime and long pepper. It is thus used throughout India, and not only by Indians but by Europeans, who acquire the habit, and slily practise it *even when they* get back to England. The tannic

acid in the interior of the nut gives it a marbled appearance, and sometimes these nuts are made into buttons. Then there are a great number of medicines in the Materia Medica of the Pharmacopœia, all of which depend for their medical properties upon the tannic acid they contain. The old physicians had their long lists of substances, which they thought all had different properties, and which, when they came to be examined, were found to depend for their medical properties upon tannic acid. I suppose the doctors now prescribe tannic acid instead of the old plants from all parts of the world. If they do not, they ought.

There is no skin that is not composed in the way I have mentioned, having more or less the characteristics of the human skin. Human skin may be tanned, but it resists tanning to the last, and requires much longer treatment than other skins. The hide of the iguana, and the hides of whales, hippopotamuses, and other creatures, have been sometimes submitted to the process of tanning; but these do not come into the regular business of the tanner.

One of the most important articles of this business are horses' hides, from America. You know that throughout the Pampas of America there are men constantly employed in horse-hunting, from which we get tallow, skins, and bones—no part being lost. Those skins come to us dried or preserved in salt—not only horses' hides, but all other kinds of hides: ox-hides and sheep-skins, and so on, can be imported in this way. Then we have ox-hides, which are employed for the soles of shoes and for harness. Horse-hides are used principally for *ladies' shoes*; while cow-hides are used

for soles. Then the calf-skin is employed for making softer leather, which is used for the upper parts of leather shoes. Sheep-skins are used for making what are called chamois and morocco leathers. Lamb-skins are employed principally for making gloves. Then we have deer-skin, used for the finer kinds of morocco leather, for bookbinding and other ornamental purposes. The calf-skin used for making the upper-leathers of boots and shoes is dyed on the outside by means of the sulphate of iron. Goat-skin is used for morocco leather. Many of these skins are split, and are then called "skivers," which are used for a variety of purposes where thin leather is required. The goat-skin is used in various parts of the world for making bottles; such bottles are used in the East for carrying water on the backs of camels; they are similar to those mentioned in Scripture, where our Saviour speaks of not putting new wine into old bottles, lest the bottles break, and of putting new wine into new bottles, and both are preserved. To understand the reference, you must recollect that it is to this kind of bottles that allusion is made. Seal-skins are imported into this country in prodigious quantities; 600,000 seal-skins have been imported into this country in a single year. They are used for the purpose of making black enamelled leather, for making boots and shoes of a higher kind or quality; they are also employed for bags, dressing-cases, and a variety of ornamental things. This enamelled leather is made by the addition of a peculiar kind of varnish on the blackened surface. Then there are such skins as the *hog*-skin, which will not tan very well, because of the

large quantity of fat which it contains, and which resists the action of tannic acid; but it is employed extensively for making saddles. Then we have the buck and the doe-skin, for making gloves and gaiters; and the French catch rats very extensively, and make use of them for converting their skins into leather. If you are anxious to avoid the fact of appearing in a ball-room with rat-skin gloves, you may know them from other skins by the fact, that sometimes, in preparing the gloves, they leave a hair or two upon the surface of the skin, which has not been cut off, and by putting these under the microscope, you can, by the peculiarity of the hair, detect the kind of skin used. Then, you see, it is not one kind of skin alone that can be employed in making leather, but every kind; for there is none that does not submit to the action of this tannic acid.

With regard to the preparation of the skins for tanning, the processes are more mechanical than chemical. It certainly looks at first sight a remarkable operation by which these pieces of skin are converted into leather. The one substance so elastic, so durable, and the other so liable to decay. Skins are called by various names. The tanner does not speak of all his materials as "skins;" he applies that term technically. Small skins, such as those of calves, dogs, rats, cats, and mice, he calls "skins;" but when he makes leather from the full-grown ox, he calls it a "hide," or from the two-year-old animal, a "kip;" and thus he divides them: and it is a practical difference, for he treats them in a different way. When the skins are salted, they are put into water; but when they are dried and not salted, they

are also put into water, which, were they left, would in the course of time render them extremely unpleasant. You may have seen a dead dog in the Serpentine. If you rub his back with a stick, you tear off the hair. The layers of the epidermis are easily decomposed in the water, and there is a tendency in them to a putrefactive change. Sometimes there is no other preparation than putrefaction, but generally, the softening is produced by a process of liming, which assists in carrying off the hair and the epidermis. I say liming, because it is the process most in use in this country; but sulphuric acid, acetic acid, all sorts of garbage, and the refuse of our swill-tubs, which produce an acid by decomposition, may be used in assisting to get rid of the hair.

When the epidermis directly under the skin is got rid of, the subcutaneous adipose tissue, which retards the action of the tannic acid, must be also scraped away. After these processes the application of the tannic acid comes. The skins are placed in contact with the barks or substances containing tannic acid, and there are two ways of applying them—dry and wet. If dry, a quantity of spent bark is taken, and some fresh bark is placed upon it; and then the hide, then some fresh bark, and then a hide, and so on, until at last, a quantity of water is put in, and the hide is left to the action of the tannic acid.

Then there is a way of putting the hide directly into the tan-pit. A cold solution of tannic acid is employed, and you put the hide into that sometimes for eighteen months or two years; and the longer the process goes *on, the better* for those who buy the leather. This is

a long process, and it is only persons who can afford to wait for a return for their money for two years, who can engage in such a trade.

Various processes have been recently introduced for facilitating the converting of hides into leather. Numerous patents have been taken out to hasten the passage of tannic acid through the pores of the leather —but then it turned out that these leathers did not wear so well, so that the old tanner has got the better of the young tanner: but the new processes are still going on contending with the old; and you will find in Leadenhall Market that leathers are tanned in all sorts of ways. One of the last new processes I would mention, is that employed by Mr. Squire, of Warrington. Large wooden cylinders are erected, and into these wooden cylinders the hides are introduced; a quantity of warm infusion of tannic acid is then put in, and the cylinders are turned round rapidly, so that the hides are beaten about in the midst of a quantity of warm infusion of tannic acid. Now, here you have combined three things which are necessary. In the first place, there is no doubt that warmth, when it does not reduce the quality of the leather, is a thing which hastens the action of the tannic acid on the gelatinous hide. It is possible that the warmth may convert the gelatinous substance into gelatine, and that the tanno-gelatine thus formed may not be so durable as the leather made cold; but there is no doubt about its facilitating the process. Then, again, there is the constant agitation, which effects a more rapid union than the quiet lying in the tan-pit, and which is certainly a clear gain. Then I told you

just now that the tannic acid was converted into gallic acid by exposure to atmospheric air. Here you get rid of that action. But I do not know whether this is a good speculation, or whether the leather fetches as high a price; but I have been informed that the leather is as good as that obtained by the old process.

After the tanning, some leathers are curried. This consists in first shaving the skin to the required thickness by a knife peculiarly made for the purpose; after that it is covered with cod-liver oil and tallow, technically called "dubbing," and hung up to dry; after which it is finished off with pumice-stone and various other proceedings. Those parts which are used for soles are not curried. Then there are various operations afterwards carried on; such as dyeing, enamelling, and so on. These are not very complicated. Split leathers are dyed; and for this purpose they use cochineal for red, iron for black; and other substances which dye wool will dye leather.

Leather can be made without tannic acid. There are two substances which will effect this change in leather; one is alum, and the other is oil. Alum is formed of sulphuric acid, potash, and alumina. The skin is immersed in salt, and salt is chloride of sodium. Now, by the introduction of the skin into the alum with the salt, a chloride of aluminium is produced, and this substance is insoluble; the consequence is, that you get the leather of a softer and as durable character as when made by tannic acid.

So also leather can be made with oil. It is known by the name of chamois and buff leather. The chamois skin is not always used; for sheep, deer, ox, and other

skins are employed for this purpose. This leather is prepared much in the same way to begin with as for tanning, by taking off the hair and fat, and then oil takes the place of tannic acid. You know we keep anchovies in oil, and olives in oil—we can keep anything in oil; and thus skin is thoroughly impregnated with oil to make it keep, and afterwards washed with alkali, to remove the greasy condition.

Mr. Preller, of Bermondsey, by his process, prepares the skins first by the introduction of starch, gluten, albumen, and things of that kind, and afterwards finishes them by the oil process. The skin is fulled by means of machines, such as are used for fulling cloth. Sometimes they are put into large tubs, and rubbed by hand. Sometimes men get into the tub, jump, and knock them about with their naked feet. Sometimes they are prepared with the hair on—two are sewed together, so that the hair of each is in contact with the other. The prepared skins are called leather, although they have never been tanned.

Russian leather, which smells so pleasantly, is prepared in the usual way, and then tanned with willow bark; it is put into a solution of red sandal-wood, and then, while the process of currying is going on, the oil from the birch is said to be introduced, but I believe this oil of birch is scented by the sandal-wood.

I cannot now go into detail about the application of leather. There is one remarkable application of leather, in which everything else has been tried and failed, and that is the making of mill-bands. These are used for making those revolutions in the wheels of our machinery, without which the manufacturing in-

dustry of this country would come to a stand-still. Then we have the harness-maker's shop, with saddles and collars, and all the apparatus for the management of the horse, made of leather. Then there is the cabinet-maker, who covers chairs and sofas with leather. Railway-carriage seats are covered with leather. Then there is the beautiful ornamental leather-work, carried on so successfully in this country. The leather is stamped and made into a variety of forms to imitate every kind of carving. Another great use of leather is the making of gloves :—

"Kid and lamb-skins are those chiefly used, but buck and doe-skins are also employed for the stronger kinds. At Limerick they are notable for making what are called chicken-gloves, from the skins of very young calves, and packing each pair inside a walnut-shell, fastened with a little silk riband, which are retailed at 5*s.* each pair, thus enveloped. It is estimated that 12,000,000 pairs of gloves are annually made in the United Kingdom, besides which we import about 4,000,000 pairs annually. There is an old proverb, that a good glove should be of Spanish leather, cut in France, and sewn in England.

"The average quantity of leather gloves made in this country has been estimated at 12,000,000 pairs annually, which, at an average value of 2*s.* per pair, amounts to £1,200,000. In addition to this, we received, in 1856, nearly 4,000,000 pairs from France. Although we are well supplied with the skins of animals at home, having plenty of sheep and lambs, nevertheless large quantities are imported, and used chiefly in the manufacture of gloves.

"In 1855 we imported the following :—

	Number.	Value.
Goat	503,918	£44,071
Kid..................	695,859	100,012
Lamb	828,031	38,682
Sheep	977,970	51,211
	3,025,778	£233,976

"Therefore, as 120 skins average 216 pairs, it follows (supposing all the imports are worked into gloves) that upwards of 5,446,000 pairs of gloves are manufactured in England from foreign skins.

"In 1855 the leather gloves imported for home consumption amounted to 3,380,648 pairs, valued at £227,000; and yet our home trade supports a vast number of men, women, and children, who are employed in their manufacture; the cutting-out, sewing, binding, setting on the buttons, linings, and trimmings in large manufactories, like that of Dent's at Worcester, affording as many different branches of occupation. An instrument for glove-making has been invented, which enables the sewer to effect the utmost accuracy in this process.

"The continental glove-trade chiefly centres in Paris. The French glove-makers are said to derive a handsome profit from the use of rat-skins taken in the Paris sewers, and from the large common pound, where offal and carcasses are thrown. In 1851 gloves to the amount of £263,000 were imported into the United States.

"Beaver gloves were formerly made at Worcester and Hereford, of leather dressed with oil. The various descriptions of leathers consist of tawed or alumed leather gloves, of which kid is an example; real kid; imitation kid, made of lamb-skin; deer-skin gloves, and military gloves.

"Formerly English skins were wholly used, but now Spanish, Italian, and German lamb-skins are the principal kinds employed."

Skins are split and made into vellum and parchment. On parchment we inscribe our deeds, and on vellum all our great state documents. There are in the South Kensington Museum writings dated 1237, 1325, 1428, and 1521; showing how well these skins are adapted for receiving and retaining the important records of the history of our property and institutions. There is a curious imitation of this parchment lately introduced by my friend Mr. Warren De la Rue; it is made out of common paper. A sheet of blotting-paper—unsized paper—is dipped into oil of vitriol and water; the consequence is, that it acquires all the

properties of parchment, and can be used for many of the same purposes.

There are many other purposes to which leather is applied, and which will occur to you all. The readiness with which it may be cut and stamped has led to its extensive use in the fine arts, and beautifully-formed objects, such as birds, plants, &c., have been made out of this material. The manufacture of baskets, reticules, picture-frames, and other articles of use in leather, has lately become fashionable work for young ladies; in fact, wherever elasticity, durability, warmth, and imperviousness to water are required, there leather may be used; and when we remember the number of its applications, we feel more inclined to regard with complacence the declaration of the tanner in the fable, that, after all, "there is nothing like leather."

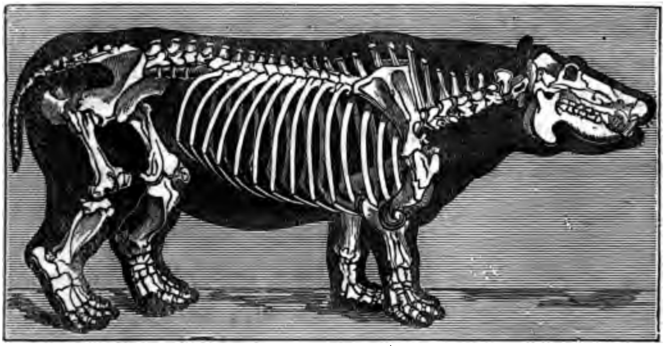


Fig. 1.

ON BONE.

Passing on from the skin of animals and its appendages, I now wish to draw your attention to those solid internal parts of the animal which we call its skeleton. The skeleton is composed of bones, which being solid, white, and durable, are used for many purposes in the arts. We find these bones which are thus used in the arts in all the classes of vertebrate animals. There are fewer used perhaps for the manufacture of solid articles of use from fish than from any other class; but, wherever animals have bones, there the same chemical constituents are found, and these constituents can be employed for a variety of purposes. It would be extremely interesting here, would space permit, to show you the contrast between the ex-

ternal skeletons of the lower animals — such as the shell-fish, the crabs, lobsters, and insects—and the skeletons of the higher animals. I might show you that just as the skeletons of insects are composed of a series of rings, the first of which develop jaws and antennæ, and the next legs and wings, so a common type develops the various parts of the skeleton of the vertebrata. Here I have (Fig. 2) what Professor Owen calls, the archetype of the vertebrate skeleton, and this supposes that a large number of pieces of this kind are united together. From the modification by growth of parts like these, we have as a result all the various forms of the vertebrate skeleton. The upper portions surrounding the part marked N form the spinal canal and the skull, which protect the spinal cord and the brain. The lower and lateral portions surrounding the space marked H form the ribs and thoracic cavity, containing the lungs, heart, and stomach; whilst the projecting lateral portions are developed into the upper and lower extremities.

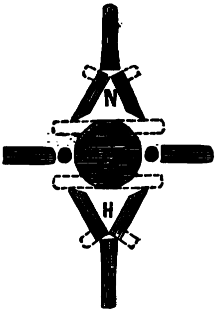


Fig. 2.
Archetype of Vertebrate Skeleton.

Now, the growth of this skeleton proceeds very much in the same way as the growth of hard parts both in plants and animals. Those who have worked with the microscope will recollect having seen in all parts of plants, in the hard part of the ivory-nut, and the hard coat of pepper-husks, a little space in the centre of the cells something like an insect with a number of legs: when-

ever hard parts are formed, cells of this kind are produced. Then we pass on to animals — the skins of insects, crabs, and lobsters, present the same cells,—so also the scales of fish; and now, when we come to the hard internal skeleton of vertebrate animals, we find the same kind of cells. They look like rows of insects running one after another. Bones are made up of this kind of cellular structure. Bones are of various kinds, —flat and round, and long and square. For commercial purposes this is of importance. The external surface of a bone is hard, whilst the internal is soft, and is called cancellated. But whether hard or soft, we get the same general structure.

Now, if we take a bone and look at its surface, we find that there are a number of rather large holes; and if you make a section of it, you will find these holes lead to canals, which are called Haversian canals, after Clopton Havers, their discoverer. These canals are represented in Figs. 3 and 4. Now, they vary

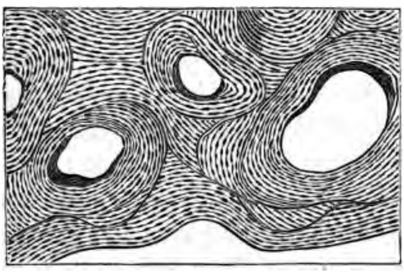


Fig. 3.—Transverse Section of Bone, with Haversian Canals.

much in size: they are smaller in the harder parts of bone, and larger in the softer parts; but whether large or small, they are always surrounded with a series of

lamellæ, which are made up of a number of little bodies

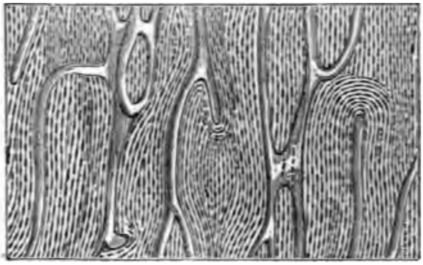


Fig. 4.—Longitudinal Section of Bone, with Haversian Canals.

represented by these black spots (Fig. 5), which are

Fig. 5.—Lacunæ and Canaliculi of Bone.

called by the anatomists *lacunæ,* and sometimes bone-corpuscles; these names show the difficulty of ascertaining whether they are hollow or solid. I think the universal conviction now is that they are hollow. Passing on from each side we have little canals, which are called *canaliculi.* They communicate one with the other. Now, between these little cells there is everywhere a common structure (Fig. 6), and under a high power of the microscope this structure presents minute six-sided bodies. Now, these little bodies are particles of phosphate of lime, which constitute the

brickwork, as it were, of the walls of these curiously shaped cells.

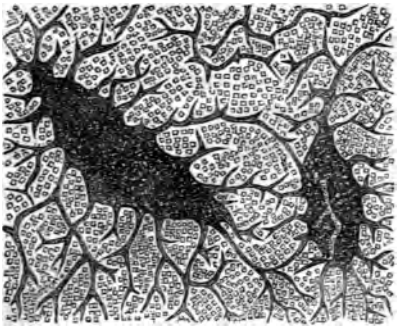


Fig. 6.—Crystals of Phosphate of Lime in Bone.

The bones are finished off with two structures, which are not immediately osseous. There is a membrane covering them, which is a fibrous membrane, called the *periosteum*. In the interior they are hollow, and contain what is called marrow. This hollowness is of considerable utility in the manufacture of the bones. The little bone-cells, curiously enough, differ in size in almost every family of animals; so that a person well informed with regard to the structure of bone under the microscope, may discover whether a minute section, hardly perceptible to the naked eye, belonged to a man, to a mammal, a bird, or a fish. We are indebted to Professor Quekett, of the College of Surgeons, now President of the Microscopical Society of London, for having pointed out a remarkable fact with regard to the bone-cells; and that is, that they correspond in size with the size of the blood-globules. You know that animals contain in their blood, cells called blood-cells, which vary in size in different animals. In

the human being the globules are the 3,500th part of an inch in diameter, and in the bones of the human being the bone-cells are the 2,000th of an inch in diameter; in birds they are about the 5,000th of an inch in diameter, whilst the blood-globules are the 6,000th; in reptiles the blood-cells are not more than the seven-hundredth or a thousandth part of an inch in diameter, and the bone-cells not more than the five-hundredth or a thousandth. There is, then, a general correspondence between the size of these two sets of cells; but there are numerous exceptions, and the statement must only be looked upon as expressive of a general relation.

Having said thus much with regard to the microscopical structure of bone, let me now call your attention to its chemical composition. The following is the general composition of bone—not of human bones or ox bones in particular, but of bone generally:—Organic matter, 40 parts; phosphate of lime, 50 parts; carbonate of lime, 8 parts; fluoride of calcium, 1 part; other salts, 1 part. You will find that the gelatine, the part which composes the organic tissue, and the fat, which constitutes the marrow, constitute the 40 parts; while the substance known as bone-earth (phosphate of lime) consists of 50 parts; and then we have common chalk (carbonate of lime) in our bones, and the bones of all the higher animals, in the proportion of 8 per cent.; and we have also a little Derbyshire spar (fluoride of calcium), 1 per cent. Why it is there we do not know; but there it is, and it is very generally present in the higher animals. Then there are sulphates of soda, potash, and magnesia; other salts about 1 part in 100.

I shall now proceed to point out the properties of these constituents, because the properties of these substances are those which render the bone so valuable in the arts. There are at least seven purposes to which these substances are applied in the arts, and each one of those has some reference to the composition of bone.

Now, first with regard to gelatine, I will not further describe it in this lecture than to remind you that it is that material of which I spoke to you at first as distinguishing the animal from the vegetable kingdom—as that material which constitutes the great bulk of the skin of animals, which, when placed in contact with tannic acid, forms an insoluble substance, —a fact which lies at the foundation of the manufacture of leather—as that substance which, when boiled out of calves' heads and calves' feet, constitutes so delicious an addition to the dinner-table,—which, when boiled down from the clippings of bones and hides, is converted into glue, or made into size, by which we bind our books, or put a hundred articles of use together. I need not describe it further, but you see how important a substance this is.

Now, taking the fat next, we shall find that it also constitutes an important element in the composition of bone. It is bad economy to throw bones away. There are persons in London willing and anxious to purchase those bones, not so much for the phosphate of lime and gelatine, as for the fat, which is applied to making candles and soap. Now, the fat exists in the hollow parts of the bones, in what is called the marrow, and very generally throughout the structure of the bone, in its cavities.

The phosphate of lime is a substance whose composition is very simple; one of its principal elements is phosphorus, which is so inflammable that we have to keep it in water to prevent its taking fire: this, combined with oxygen gas, forms an acid which is called phosphoric acid. This acid unites with lime to constitute phosphate of lime. We have phosphate of lime, as it is obtained from rocks which lie at the very foundation of the earth. This is the first source of phosphate of lime before it comes into bones. First it is dissolved by carbonic acid gas, in water, then picked up by the delicate blades of plants, then introduced into the stomachs of animals, then deposited in their bones. Even when thrown out by them, it is carefully collected by man, and thrown on to the fields where he grows his cereal plants.

The carbonate of lime is not an uninteresting constituent of bones: we can generally get evidence of its existence by pouring upon a crushed bone some sulphuric acid, which produces an effervescence. There is no effervescence from phosphate of lime, but you get it from carbonate of lime: eight parts in one hundred of our bones are carbonate of lime. There is an interesting relation between carbonate and phosphate of lime, as being the substances which chiefly contribute to the formation of the skeletons of the whole animal kingdom. In the skeleton of a coral we have a mass of carbonate of lime. In insects, crabs, and lobsters, we find a little phosphate of lime coming in; as we go higher, the phosphate of lime increases, and the carbonate of lime decreases, until we come to man, who possesses the largest amount of phosphate of

lime; but the carbonate has not been wholly dispossessed. This coming-in of phosphate of lime and going-out of carbonate of lime may be represented by this diagram: —

Man.—Vertebrate.

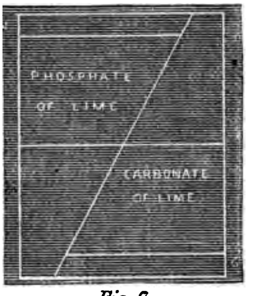


Fig. 7.

Corals.—Invertebrate.

Of course this diagram gives only an approximation to the real distribution of the salts of lime in the skeletons of the animal world. The phosphate of lime goes on decreasing as the animal is lower in the scale, until at last we find scarcely any phosphate of lime and large quantities of carbonate of lime.

Fluoride of calcium is interesting as occurring in human bones, as well as the bones of lower animals; and a very curious fact has occurred in connection with its presence, and that is, that a large number of the fossil bones of elephants and other creatures that have recently been brought from the Sivalik Hills, in the Himalaya, by Dr. Falconer and Sir Thomas Cautley, are found to contain, not phosphate of lime or carbonate of lime, but fluoride of calcium. Thus it has been supposed by some, that animals really formed their bones of fluoride of calcium, while others have conjectured that bones, whilst lying in the earth, had changed their phosphate of lime into fluoride of calcium. In order to explain this phenomenon more satisfactorily, I would call your attention to the fact, that carbonate of lime is insoluble in water; but if water becomes charged with carbonic acid gas, as it does when passing through

the atmosphere, it has the power of dissolving carbonate of lime and also phosphate of lime. We have no other means of understanding how it is that plants could take up phosphate of lime unless it was dissolved, and it appears that phosphate of lime dissolves in water containing carbonic acid gas. Fluoride of calcium, or Derbyshire spar, also dissolves in water containing carbonic acid gas, but not with equal facility. Carbonate of lime dissolves much more freely than phosphate, and phosphate more freely than fluoride: hence it comes to pass that water holding fluoride of calcium in solution, passing over a substance containing phosphate of lime, would prefer taking up the phosphate to holding the fluoride, and would drop the one and take up the other. Thus you see how elephants' bones, containing the phosphate, might lose it and have fluoride deposited in its stead. In the secondary and tertiary rocks of the earth, we have deposits of phosphate of lime, under the name of coprolites. They are collected and sent to the agriculturists, and used for manure. How do these deposits occur? Why, water containing carbonic acid gas and phosphate of lime, has percolated through the strata containing these bodies, and carried away the carbonate of lime, and left behind them this precious phosphate of lime for the preservation of our lives and the increase of our race.

Then, besides phosphate and carbonate of lime and fluoride of calcium, we have certain salts whose presence does not render the bone more useful in the arts. There is magnesia, which must be there, and disease takes place when it is absent; and so with the other salts.

But we may leave these and look now to the uses to which the other substances are applied.

In the first Lecture I mentioned to you that we might make a class of those things which were applied to the production of solid articles of use: and all solid substances are applied to some useful purpose. For instance, shells are used for forming the handles of knives; wood is also used for the same purpose; so are bones and ivory. There are a great number of uses of this kind to which bone is applied. There is a very useful application of bone in the production of a very common article of use—buttons. These buttons are produced in prodigious quantities in the towns of Birmingham and Sheffield, and they are sent out into the world in ton-loads from year to year. They are so cheap that some of them are sold at the rate of twelve dozen for a groat, wholesale. There is no material from which buttons can be made so cheap—and every one knows their uses, and how valuable they must be wherever man is sufficiently civilized to wear clothes. Then there are bone-carvings, card-cases, combs, brushes, parasol-handles, book-holders, knives and forks, thimbles, counters, rings, and other articles too numerous to mention. In the manufacture of these articles the shavings and sawdust are not thrown away. These are collected and sold for various purposes in the arts. One purchases the bone-dust and shavings for the purpose of manufacturing size; another buys them for making a supposed nutritious article of diet. The roughest parts are gathered up and are sent off to the glue-makers and manure-manufacturers; but not a particle is lost.

I stated that phosphate of lime was composed of a certain quantity of phosphorus and oxygen and calcium. Now, although this phosphate of lime has been known for a long time under the name of *Apatite*, yet this mineral is not the substance from which we obtain phosphorus for the arts. After the gelatine has been boiled out of bones, the phosphate of lime is left, and this phosphate of lime is treated with sulphuric acid, and the sulphuric acid withdraws the lime from the phosphate, and we have left in the vessel phosphoric acid. This is mixed with charcoal in a retort. The charcoal combines with the oxygen, forming carbonic acid gas, and phosphorus is distilled. Thus it is obtained for the chemist. He uses it to illustrate a variety of processes. It enables him to perform most brilliant experiments, and by it he can show the composition of the atmosphere, the nature of combustion, and a variety of other effects which could not be so well effected by other agents. Its great use in the arts is for the manufacture of lucifer matches.

Many of you can recollect how your grandfathers and grandmothers, after much labour and patience, obtained a light by means of a flint-and-steel and box with tinder, and a match with sulphur; what a blowing there was, and what tears were often shed before a fire was lighted of a morning, and frequently of a summer evening before a candle could be seen on the table; but now all this has gone by. I can remember, when I was a lad, standing in the market-place of my native town, seeing a man come down the steps of the Shire-Hall with a tray full of little boxes of matches, which we all thought wonderful. He said he could

not sell them because the magistrates considered them dangerous. These were the first lucifers I ever saw. The magistrates forbade the man to sell them, as they considered them likely to encourage the dangerous practices of ill-disposed persons who were signing themselves by the name of "Swing." But mankind has been wiser than the magistrates, and has trusted to good sense and intelligence, and nobody feels that the world is the worse for lucifer matches.

In making lucifer matches the phosphorus is combined with one of two things—either chlorate of potash or nitrate of potash. One or other of these substances is mixed with the phosphorus and some sulphur, and having been brought to the melting-point, little pieces of wax or wood are dipped into it. Thus the phosphorus is brought in contact with a supporter of combustion in the oxygen contained in either the chlorate of potash or nitre. Although the nitrate of potash contains more oxygen for its bulk, as the atomic number of chlorine is thirty-six and that of nitrogen only fourteen, yet the chlorate gives off its oxygen gas more freely. Quiet lucifer matches are of foreign manufacture, and are made with nitrate of potash. The chlorate of potash makes more noise in giving up its oxygen. It is generally employed in the English matches.

Now, there are two kinds of phosphorus, and one of these does not require to be kept in water. The piece of phosphorus which I now show you was exhibited at the Great Exhibition in 1851, and here it has stood under this glass case ever since. It is called red phosphorus, and just in proportion to the heat to which this body is exposed before it cools down, will

be its tendency to take fire in the air. This was discovered by Schrötter. Now, the manufacture of lucifer matches is attended with a dreadful drawback to the persons engaged. Whilst heating the phosphorus, the fumes rise into the air, and they are taken into the system; and, although the action is imperfectly understood, yet there can be no doubt that the agency of the phosphorus is to act upon the bone and the solid tissues of the body, and to produce severe and fatal disease. It was hoped that a remedy had been found for this in the red phosphorus; but I understand that it is not sufficiently inflammable, and on that account is very little employed in the present day. I may, however, state that lucifer matches are made in France which only light by being brought in contact with a surface containing red phosphorus. This substance is introduced upon the rubber of the box, and thus the matches are prepared without the aid of the yellow or more inflammable phosphorus. Should that manufacture be introduced into England, I should say it would be worth a little inconvenience and trouble to encourage it, in order to get rid of an article which is really produced at the cost of the lives of our fellow-creatures.

Passing on from the manufacture of phosphorus and lucifer matches, I would call your attention to what I said with regard to the presence of fat in bones. I shall have more particularly in the next Lecture to speak of the action of fat, first upon the alkalies producing those useful substances called soaps, and then in the manufacture of candles. I would remark here, then, that bones, when picked from the streets when

perfectly useless for the manufacturer of buttons or the smallest possible article of a solid kind, can yet be usefully boiled down for the gelatine, on the one hand, and the fat on the other.

Then, when bones have been boiled, and they have yielded up their gelatine and have given up the fat they contain, there is still enough animal matter left to render it a very useful material in the formation of animal charcoal. Perhaps one of the greatest benefits those who live in the neighbourhood of bone-boileries have experienced, has been the conversion of boiled bone into charcoal. It was the practice formerly to send these bones to the manure-manufacturer, in order to be distributed over the soil; but this process was always attended with states of decomposition which rendered the bones very offensive. If you take a bone and expose it a few days, the gelatine is decomposed, and carbonate of ammonia, called smelling-salts, with other compounds, are formed; and some persons would hardly be satisfied with calling it an ammoniacal, but they would call it a demoniacal odour, on account of its intensely disagreeable smell. But the bones now, instead of being sent into the country as manure, are burnt, and thus converted into animal charcoal. This charcoal must always contain large quantities of phosphate of lime. At first sight one would have thought that the presence of phosphate of lime would have been a drawback; but it has been found that it is not so. For almost every purpose for which any charcoal is used, that from bones is found to be by far the most effective; so that now the manufacturers of filters and

sugar-refiners use bone charcoal; and we find that a large consumption of the waste bone from the bone-boilers takes place in sugar-refineries. Bones burnt in this way, after the glue and size and fat have been obtained from them, are now producing as much as £16 or £17 per ton in the market.

There is yet another use of bones, which has led to results which can hardly be appreciated or estimated by mere figures, but must really be valued in the rise of manufactures, in the multiplying of food, and in the increase of happy families in our country.

Phosphate of lime is necessary to our bones. It is therefore necessary that we should eat food containing phosphate of lime. If we do not get this phosphate of lime, our bones soften—we become mere gelatinous masses, and perish. We can get this food from the animal kingdom: beef and mutton contain phosphate of lime. But if phosphate of lime is necessary to the existence of these creatures, where are they to get it? From the grass and the corn of the field. And we also must not depend upon the animal kingdom. We must obtain it from our vegetable food—in our wheat and other vegetable substances. We know that the farmer grows a rotation of crops, and every now and then he renews the fertility of the soil by manures, because the plant exhausts the soil of the phosphate of lime. Therefore, wherever there is phosphate of lime to be found, either in the refuse of the bone manufacturer, or any other place, it becomes valuable as manure; and it is the discovery of this fact which has led to the use of a variety of substances as manures formerly unknown. The farmer now uses crushed

bones and other substances containing phosphate of lime. But we have also mineral sources of this phosphate of lime. We get from Sweden and other places large quantities of the mineral apatite. It exists in the province of Estremadura, in Spain, and might be made of more value to that country than all the gold she obtained in her conquests in the New World.

Then there are the substances called *Coprolites,* found on the coast of Essex and Suffolk, and the Greensand and Wealden formations. They have been formed out of the phosphate of lime which was once contained in the bodies of gigantic whales, reptiles, and fishes. These coprolites are not the excretions of these animals, but they are nodules of phosphate of lime, which have been formed by layers deposited from water which first washed and then held in solution the phosphate of lime from the skeletons of these huge creatures. What a grand view this opens up to us of the relation of created things. Thus, the very particles of matter that compose our bodies to-day, may have formerly been present with the ichthyosaurus in his piscine feasts in the depths of a Liassic ocean, or rolling about in the body of some whale that lived in the sea which deposited the clay on which our house now stands.

Before these forms of phosphates are used as manures, they are reduced to the condition of a super-phosphate. This substance is made in the simplest way. These coprolites, or the apatite, are ground down, and are then treated with sulphuric acid enough to take away one portion of the phosphoric acid. By taking away a part of the lime by the sulphuric acid, we leave a

bi-phosphate, which is the form in which plants take it up. Hence the manufacture of super-phosphate of lime; and in country places large manufactories of this substance are springing up. Just wend your way to the eastern coast of Suffolk. You will see there large loads of sulphur and nitrate of soda, and these are used for the purpose of making sulphuric acid, which, being mixed with the coprolites, convert them into super-phosphate, for the purpose of manure. So much, then, for the form in which the phosphate is applied to the earth.

Another set of substances obtained from bones are ammoniacal salts. Ammonia consists of nitrogen and hydrogen, and it may be obtained from gelatine, or any decomposing animal matter. If you take any animal matter, as dead dogs, cats, mice, pigs, and so on, and put them into a retort, you will get not only nitrogen and hydrogen, but carbon and oxygen; and thus you may form carbonate of ammonia. By adding hydrochloric acid to these substances, you obtain hydrochlorate of ammonia, or sal-ammoniac.

I will now ask your attention whilst I speak of the nature of ivory. Ivory is a substance very much like bone; but, having a finer texture, it is more delicate in its appearance, and it has the power of enduring longer, and, therefore, of recompensing the labour of the artist, and commanding a higher price in the market: so that ivory is used much more extensively for works of art. It has always been a favourite material for carving. We find it used among the Chinese for this purpose. These people seem to think no labour too much to produce these curiously-carved articles. Their

ivory balls, carved one inside another from one piece of ivory, are marvels of patience, industry, and ingenuity; and most elaborate ornamentation is put upon ordinary things made of ivory; such as chessmen, cabinets, drinking-cups, and other things.

In order to enable you to understand the nature of ivory, I must speak of the structure of teeth generally; and I will first describe the construction of human teeth in illustration. Here is a human tooth—a canine tooth as it is called (Fig. 8). It consists of three parts —the upper outside part is called the *enamel*, and the inside part the *dentine*, and the lower outside part, which covers the fangs, the *cementum*. In the interior of the dentine is the pulp, which contains the delicate vessel and the nerves; and it is the exposure of this little nerve which gives us the pain called the toothache. Now, these teeth are connected in all the higher animals with the jaw; they sink down into the bone, and we thus distinguish the teeth of the mammalia more especially from those of the lower creatures, by the fact of their sinking down into the sockets of the jaw. They are called *neural* teeth, in contradistinction to the teeth of fish, which are called *dermal* teeth, and which grow upon the surface of the mucous membrane. Now, taking the gnawing teeth of the gnawing animals (*rodentia*), —as rabbits, hares, rats, and mice, we have two teeth projecting from the upper jaw, and two meet-

Fig. 8.
Section of Human Canine Tooth.

ing below. These teeth are formed with the hard enamel on the outer surface, and with the softer cement on the inner surface (Fig. 9); so that by the wearing away of the inside, the outer thinner layer projects, and the tooth is constantly kept sharp.

Fig. 9. *Tooth of Rodent.*

Then, in the ruminant and in the pachydermatous animals, we have an arrangement of the parts, such as is seen in the elephant's grinding-tooth. The plates of enamel are set in a mass of cementum. The latter giving way before the enamel, the consequence is, they are always kept rough. (Figs. 10, 11.) If you had a pave-

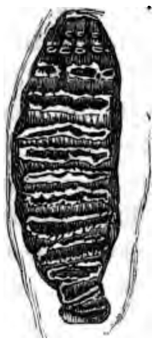


Fig. 10.—*Tooth of Asiatic Elephant.*

Fig. 11.—*Tooth of African Elephant.*

ment with a soft substance and a hard substance, you would constantly have a rough surface. This has been lately introduced by inserting wedges of iron into wood, just as the enamel is inserted into the cementum; and the wood continues wearing away. The chemical composition of the teeth is very like the chemical com-

position of bones; but I would draw your attention to the curious fact, that the enamel contains a very large or greater quantity of solid matter than the dentine or cementum. The enamel contains only 4 per cent. of organic matter against 40 per cent. in the bones, and 30 per cent. in the dentine and 39 in the cementum. A curious circumstance in the history of the teeth is, that the enamel contains a small quantity of silica or flint. It is only in small quantity, but it gives hardness to the enamel; and the want of this silica in the teeth is productive of a wearing away, and eventually a loss of the teeth altogether. Thanks to the art of the dentist, we can readily get new teeth: for this purpose he uses the teeth of the lower animals.

It is not, however, all teeth that can be used by the dentist, nor do all teeth yield what we call ivory. Those teeth to which we more particularly give the name of ivory are the tusks of the elephant; and the tusk of the elephant is so constructed that the whole of the outside of the tooth consists of dentine—of that matter which we find in the interior of the teeth of man; and this dentine is a substance which stands between the cementum and the enamel in its solidity and its chemical composition. It is on this account that we find it so useful in the arts; but the dentine of other animals is not so valuable as that of the elephant. We thus have the walrus, and the narwal, and other animals, which have dentine closely resembling the ivory of the elephant, and they serve the purposes of the dentist, but they are not generally used for ivory manufactures. The microscopic structure of the ivory of the elephant explains why it is so valuable as compared with others. If you

supposed the cells we saw in bones elongated, you yet would get a structure something like this (Fig. 12).

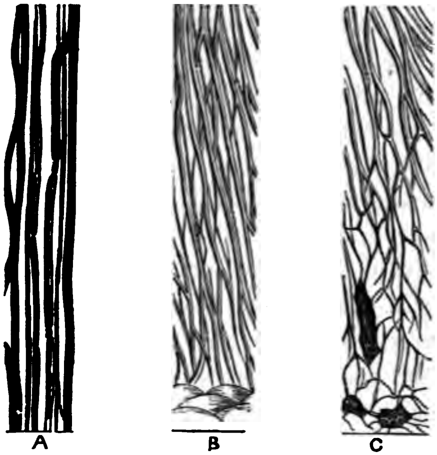


Fig. 12.

A. *Large Dentinal Tubes.* B. *Fine Dentinal Tubes.*
C. *Dentinal Tubes and Bone-cells.*

The little canals of the bone-cells are represented by these little stripes, which are really tubes. Now these tubes are not generally more than the ten thousandth part of an inch in diameter, and being closely packed together, constitute the structure of ivory. It is its dense character which gives it its superior value. The tubes are also curved, in ivory, which they are not in the case of other teeth; and this is another cause of the value of the ivory of the elephant.

Fine ivory is known by having no cracks or flaws either in the solid or in the hollow. Cracks in ivory are a serious detriment, and must be always particularly noticed. The elephant's tusks that are only

rather tapering in shape are most liked; very crooked teeth must be guarded against, as they cut up to great disadvantage. In many tusks there are marks about the centre which are called shots: they are caused by the bullets of the Africans, and flaw the ivory two or three inches round the ball, and considerably diminish the value. Broken-pointed tusks, or those with deep flaws, or otherwise damaged about the point, must be avoided. Tusks with large hollows are not at all liked, as there must inevitably be a great waste in cutting them up; in short, a fine tusk is known by being of a neat tapering shape, and a small hollow, free from cracks, with a fine, thin, clean coat, free from flaws, &c.: it is also transparent; which may be discovered by holding the point to a candle. The Gold-Coast ivory may generally be known by having a rough-hewn hole made near the end of the hollow; and this ivory is much esteemed.

The London dealers classify the tusks into the following sizes:—

Firsts, or those ranging from 70 to 90 lbs.		
Seconds, weighing about 56 lbs.		
Thirds	„	38 „
Fourths	„	28 „
Fifths	„	22 „
Scrivelloes, all under		20 „

The tusks and teeth of the elephant—the latter, for the sake of distinction, are termed grinders—are formed after the ordinary manner of the teeth of animals. The organism which converts the earthy constituents of the blood into cellular tissue and membrane, contributes in the same way to form the

teeth by the successive depositions of layer upon layer of the soft vascular pulp. The marks of these depositions, or laminæ, are clearly distinguishable in the longitudinal striæ of the section of a tooth. The tooth is hollow about half-way up, but a very small tubular cavity is visible throughout its entire length. This, sometimes called the nerve, is in reality the apex of successive formations in the process of growth. The grinders are seldom used in the arts. They are of a different texture, the laminæ more loosely combined and possessing a tendency to separate, which renders them unfit for nearly all useful purposes.

The greatest consumption of ivory is undoubtedly in connection with the cutlery trade. For these purposes alone about two hundred tons are annually used in Sheffield and Birmingham; and the ivory in nearly every instance is from India. The mode of manufacturing knife-handles is very simple and expeditious; —the teeth are first cut into slabs of the requisite thickness,—then to the proper cross dimensions, by means of circular saws of different shapes. They are afterwards drilled with great accuracy by a machine; riveted to the blade; and finally smoothed and polished. This branch of industry alone gives employment to about five hundred persons in Sheffield. Combs are seldom made of any ivory but Indian. A large amount of ivory is consumed in the backs of hair-brushes; and this branch of the trade has recently undergone considerable improvements. The old method of making tooth-brushes, for example, was to lace the bristles through the ivory, and then to glue, or otherwise fasten, an outside slab to the brush for

the purpose of concealing the holes and wire thread. This mode of manufacture has been improved on by a method of working the hair into the solid ivory; and brushes of this description are now the best in the market. Their chief excellence consists in their preserving their original white colour to the last, which is a great desideratum. Billiard-balls constitute another considerable item of ivory consumption. They cost from 6*s*. to 12*s*. each; and the nicety of our ornamental turning produces balls not only of the most perfect spherical form, but accurately corresponding in size and weight even to a single grain.

The ivory miniature tablets, formerly so much in use, and which are so invaluable to the artist, from the exquisitely delicate texture of the material, are now produced by means of a very beautiful and highly interesting chemical process. Phosphoric acid, of the usual specific gravity, renders ivory soft and nearly plastic. The plates are cut from the circumference of the tusk, somewhat after the manner of paring a cucumber, and then softened by means of the acid. When washed with water, pressed, and dried, the ivory regains its former consistency, and even its microscopic structure is not affected by the process. Plates thirty inches square have been formed in this way, and a great reduction in price has thus been effected.

From the great value of the material, the economical cutting of it up is of the last importance. Nothing is lost. The smallest fragments are of some value, have certain uses, and bear a corresponding price. Ivory dust, which is produced in large quantities, yields a

most valuable gelatine, and as such is extensively employed by straw-hat makers.

The scrapings, shavings, or sawdust of ivory is an article that bears a good price in the market, being much used by pastrycooks and others as a material for jelly, which it readily gives out to boiling water. The jelly thus produced is probably quite as good as that from calf's foot; and the shavings, when dry, have the advantage over calf's foot of not suffering any change by keeping. Another use, of considerable importance, to which bone shavings are applied, is in case-hardening small articles of steel.

In the teeth of the cachalot whale, and of the narwal and other large-toothed animals, we do not find the tubes so dense or curved as in ivory, and consequently they are not of the same value in the arts.

The enamel of teeth is composed of dense prisms

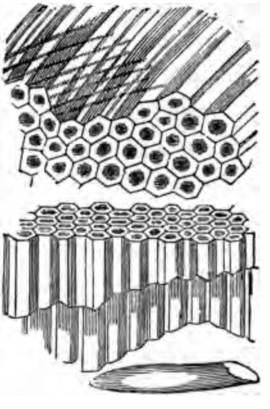


Fig. 13.—*Enamel.*

(Fig. 13), which are so hard that they are cut with difficulty: when thin sections are made and placed

under the microscope, the whole enamel is seen to be formed of minute six-sided prisms.

The elephants from which we derive our supplies of ivory are the Asiatic and African elephants, the only two species which exist at the present day. The African yields tusks of greater value than the Asiatic. The tusks are the canine teeth of the animal; and it is the male alone in the Asiatic form that possesses tusks; but in the African species both sexes have tusks, and these latter yield the finest ivory. The tusks of the extinct mastodon occur in some places in such large numbers that they are used for ivory; but their dark colour is a drawback on the value of the ivory they yield. The tusks of the hippopotamus and the narwal, and the teeth of the cachalot, have been employed extensively by the dentist; but they have recently undergone an extreme depreciation in value, for the dentist has found a substitute for these teeth in gold and vulcanized india-rubber, which he makes into parts representing the gums and the roof of the mouth; whilst even for the teeth themselves a mineral compound is employed, which renders them harder and more durable than any form of dentine or natural tooth.

Fifty thousand elephants' tusks, weighing 10,000 cwt., are imported every year; consequently, no less a herd than 25,000 of these magnificent animals must die every year to supply the English market alone.

Well, in this, as in so many other instances, you see how curious and interesting are the relations of man to the animal world. Underlying all the wonderful forms which the animal kingdom assumes in obedience to

definite morphological laws, we find that the materials out of which the bodies and organs of animals are made, possess certain physical and chemical properties, so altered and so arranged by their vital conditions, that they become of use to man in his civilization. It would seem, when we study these wonderful adaptations to the wants of man, as though either every creature was formed first for itself and then for man, or that man was so constituted that, in the course of his history, he should be able to render every creature by which he is surrounded subservient to the purposes of his existence.

Fig. 1.

ON SOAP.

In this lecture I wish to draw your attention to some other organs or tissues of the animal kingdom. In previous lectures we have spoken of the hairs of the higher forms of animals, of their skin, and their skeleton, and now I would point out the fact, that between the skeleton and the skin there are a number of organs depositing materials which are of great value to man.

The substance to which I shall more especially allude, is that with the absence of which we are so familiarly acquainted when we speak of a man as nothing but skin and bone. When he has much of this material, we speak of him as being well fed, and in good condition, according to the quantity he possesses of this material — fat. It is called adipose tissue, and no animal exists without this substance to a greater

or less extent; and in no case where it exists naturally is it useless. Although we throw away a great quantity of this animal matter as refuse, it could be made useful in the arts. To give you one illustration, I may mention that some three or four years ago a decree went forth in Paris that all dogs that had not owners should be shot and thrown into the Seine, and there they were in thousands and tens of thousands; but the chiffonniers of Paris found out that the dogs had fat, and they collected the dead dogs and boiled them down and separated the fat, which turned out to be very valuable. The quantity of fat thus collected was about one million of kilogrammes. It was more particularly employed in the preparation of kid gloves. It sold at the rate of two and a half francs the kilogramme.

I shall endeavour to impress you with the necessity of a knowledge of the fact, that there is nothing that exists in the form of an animal, that may not be made use of,—that the material elements of which it is composed are of such a nature that they may be applied for a hundred purposes for which man employs the external world. Then let us examine this adipose tissue.

We find it existing in various parts of the animal body; and when we take a portion of fat of any kind of animal, and examine it under a microscope, we find a quantity of cells called fat-cells, which lie amidst the filaments of this tissue, which is called cellular or areolar tissue. (Fig. 2.)

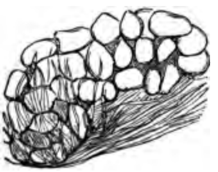


Fig. 2.

Now, these cells are everywhere thrust, as it were,

into the network of the tissue of which the body is composed. The fat of itself does not compose living organs. If you could get at the fat without piercing through the skin, there would be no feeling in it at all. It is deposited in these cells; and there it lies, the cells not getting larger, but increasing in number, the fatty substance being independent of the living tissues of the animal. The tissues around are abundantly supplied with blood-vessels; but the blood-vessels do not pierce these cells. The nerves also run through the tissues, but not through the cells; so that these cells are like the epidermal cells—independent of the structure by which they are surrounded. Now, the matter contained in these cells has a variety of names, according to the circumstances under which it is presented to us. It is called tallow when it is melted down, and it comes into the markets under this name. It is called *lard* when it is prepared for food, more particularly as procured from the pig, and pork lard is a well-known form of fat. It is called *grease* when it is the refuse of fat. Sometimes this grease is mixed with other materials, and then it is called *kitchen stuff*. It is called *suet* when it is hard, and *fat* when it is soft. It is called *butter* when it is soft and separated from milk, and *oil* when it is liquid. There are animal oils and vegetable oils. Before speaking of the chemical composition of this substance, I will explain how this fatty matter gets into the animal tissue.

You will see at once, by looking at a table of our food, that we take in it a very considerabie quantity of fat. We take butter with our bread; and then we

prefer meat with fat, or meat that has been fed well; and, taking the leanest part of our meat, it is penetrated with fatty matter. There is fat in fish. Maize contains 7 per cent. of fat. Barley, oats, wheat, and rye, all contain certain portions of fat; so that if we would, we could not avoid taking a certain quantity of fat. The ox and the sheep get their fat directly from the grass upon which they are fed, as oil is found in these things. But there is another source, and that is, the starch and sugar which all herbivorous animals eat. Starch has not the same composition as fat. Fat is composed of—

Carbon	11	parts
Hydrogen	10	„
Oxygen	1	part

But let us look at the composition of starch and sugar; it is—

Carbon	12	parts
Hydrogen	10	„
Oxygen	10	„

Animals are constantly taking these substances in their food. All grasses contain large quantities of starch and sugar. Thus, quite independently of fat, we find the starch and sugar capable of supplying the materials of fat. You see, if we reduce the quantity of oxygen in starch and sugar by nine parts, we have a substance chemically resembling fat; and it would appear that animals, when they take larger quantities than they require of sugar and starch, convert them into fat. Ani-

mals eat more starch and sugar in the summer time than they need to keep up their heat, and the consequence is, that they are converted into fat; but this is lost in the winter. This was at one time denied by the French chemists, and they maintained that animals obtained the fat they had from their food; and we are mainly indebted to them for the knowledge of the fact, that so many plants contain oil, as they sought, in opposition to the Dutch and German chemists, to maintain this theory. Liebig, however, brought forward the celebrated case of the Strasburg goose, which is used for making the famous *pâté de foie gras.* The way they make these pies is to take a goose and put it down upon a board; its wings and legs are then extended and fastened to the board, in a sort of way in which a human being is placed when crucified. But they treat him, as dear old Izaak Walton recommends his reader to use the frog, for bait, "as though they loved him." He is put before a large fire, not to roast, but to keep him warm, and all the time they feed him well. You know the consequences of feeding people well and keeping them warm. They will get fat, especially if they do not take any exercise. Now, that is just what takes place with this goose; and fat being formed from the starch of the barley-meal on which the goose is fed, and not being wanted in any other part of the body, it at last finds its way to a very distensible organ, the liver of the goose, which keeps growing and growing, until at last it nearly kills the animal. It is then taken out and made into the delicious *pâté de foie gras.* Now, said the German, here is the fact proved of starch being converted into fat. But

other proofs are known of the fact, that starch and sugar are really converted into fat.

Now, let me say a word or two with regard to its use in the animal system. Fat is developed much more largely in young people than in old ones. As the fat retires, the angles of the bones begin to be perceived, and what we call ugliness takes place. It is thus an essential element in the beauty of the human form. Then it is a bad conductor of heat. If you take a piece of iron and a piece of fat, and touch them, you will find the iron feels coldest, as it is a good conductor of heat, but the fat feels warm. It is thus supplied to animals in regions where it is very cold, to keep in their heat. We find in the bear and other polar animals large quantities of fat. It serves the same purpose in the great Cetacea. In the whale, the fat is a foot or more in thickness, which prevents the lowering temperature of the water, and it also gives them a lightness by which they are enabled to swim in the water with little effort. There can be no doubt that this fatty tissue is of use to all aquatic animals, by reducing their specific gravity, and thus enabling them to swim with facility in water. Fat is also a store of fuel for animals; and this is a provision for the winter season, when their food is less abundant, and when it contains less of the materials by which they can be heated. That the fat is used in this way, is seen from the fact that animals are always thinner in the winter than in the summer, because they have used the store of fuel put upon their backs.

That fat acts as fuel in the animal system there can be no doubt; for we find that it is the best thing we can

employ for combustion. It contains both carbon and hydrogen, which are the elements we employ for lighting and heating in the gas from coal; and we can get the same gas from oil, though coal is the cheapest. Then, just as these things supply us with the means of artificial combustion, so they supply us with materials for natural combustion. They get into our blood, and we take in oxygen by our lungs, and thus they are burnt in contact with the oxygen in the body; and in this way all animals consume large quantities of fat. Just as a man passes from tropical to cold climates, he consumes fat. In the regions of eternal snow, man eats large quantities of fat, for the purpose of keeping up his heat.

Fat also has another property. It seems necessary to the proper nourishment of the animal body. We find the fat-cells surrounding every tissue; and where there is a deficiency of fat, there we find a deficiency of other tissues. In disease, fat ceases to be developed, and recently fish and other oils have been introduced, for the purpose of being used as medicines, in diseases in which there is a tendency to lose fat. In consumption, this is especially the case, where we find persons getting thinner and thinner every day; but, by administering this oil daily, the fat is deposited again, and with that fat there is a tendency to develop those tissues on which the strength of the body depends. The only well-authenticated cases in which consumption has been suspended for any length of time, is where cod-liver, or some other animal oil, has been administered. This is the reason why the cod-liver oil has been so generally used.

Fat is found in the eggs of birds and in the eggs of insects. In fact, in the very lowest animalcules we find oil. So much, then, for the uses of this substance in the animal system.

I now come to speak of its chemical composition. It assumes a variety of forms,—fat and lard, suets, tallows, greases, butters, and oils; and one would think that the chemistry of these substances was one of the most difficult problems with which we could deal; but, thanks to recent chemistry, we are enabled to explain this subject in a very simple manner. It was in the latter part of the last century that the German chemist Scheele obtained a substance which he called the "sweet principle of oil;" but it is to a French chemist named Chevreul to whom we owe all we know of the chemical properties of this substance, and the true nature of oils and fats. He has recently collected his papers on this subject and published them in a volume, which is, perhaps, unique in the domain of chemistry, on account of the value and importance of the discoveries it announces. The French government thought so much of the discoveries of Chevreul, that they presented him with 12,000 francs. This is a gratifying recognition of the debt society owes to great discoverers, who, whilst contributing to the fortunes of others and the welfare of society, are seldom paid with anything more substantial than words.

I will now proceed to explain the general composition of oils and fats wherever they are found. Eleven proportions of carbon, ten of hydrogen, and one of oxygen, indicate a formula which may be applied to the whole family. Taking these proportions, and putting them

down according to their atomic weight, we shall have—

Carbon	66
Hydrogen	10
Oxygen	8
	84 oil of fat.

In 84 lbs. of fat, whatever may be its source, there will be 66 lbs. of carbon, 10 lbs. of hydrogen, and 8 lbs. of oxygen. These substances are not, as you might suppose at first sight, simply mixtures of carbon, hydrogen, and oxygen; but they are really compound bodies of the same nature as carbonate of ammonia. Carbonate of ammonia is composed of one part of carbonic gas and the other part ammonia; and you know if I take it and put it into a vessel, and then pour on it nitric acid, I shall drive off the carbonic acid gas. The carbonic acid gas comes bubbling off as quickly as possible, and you get nitrate of ammonia. And so, when we take carbonate of soda and add tartaric acid, we get tartrate of soda, and the carbonic acid gas flies off. The composition of oil is of the same kind. It is a compound body like carbonate of soda. The soda is represented by a body called glycerine, or oxide of glyceryle, and the carbonic acid by a fatty acid, stearic or oleic. When soap is made, an alkali is added to the oleate of glycerine, and the alkali combines with the acid and sets free the glycerine. Soap is the salt of a fatty acid. In the same manner glycerine is removed from oils, and the stearic acid which is left, is used for the manufacture of candles.

If you take such an oil as palm oil, or what is better,

olive oil, and set it out in the cold weather, you will find that a white substance falls to the bottom, and that substance the chemists call stearine. The clear transparent fluid part is called oleine. Now, if you take human fat or goose fat—for it does not signify which, and allow it to melt, you will get not oleine or stearine, but another substance, called margarine, which very nearly resembles stearine. I shall not stop here to point out the distinctions between them, except to say that margarine is contained in the human body and is contained in the goose also, but that stearine and oleine are most commonly found in both the animal and vegetable kingdoms.

These bodies, then, are all compounds of an acid and a base. The stearine, as I have said, is composed of stearic acid and glycerine; the margarine of margaric acid and glycerine; and the oleine of oleic acid and glycerine: so that you see glycerine lies at the base of all. I would here call your attention to the fact, that this glycerine is not an inflammable body. But you know what an inflammable body fat is; and, as an illustration, if you take one each of all the candles in the present day that are manufactured from this fatty substance and test them, you will observe that those candles burn best which are made of the fatty acid after the glycerine has been got rid of.

There is another substance which is used for making candles and burning in lamps, which is not an oil at all. This substance is called petroleum. It is at the present day brought largely from the East Indies. It is a mineral production, that is to say, it comes out of the earth, and consists of carbon and hydrogen. From this

is formed a substance which we call paraffine, and this may be obtained in a gaseous, liquid, or solid form. The belmontine of Price's Candle Company is paraffine, and candles are made of it when solid; so that you see this mineral substance has come into competition with oil in the manufacture of candles; and, in speaking of oil, sometimes people speak of this as a mineral oil. But we cannot make soap out of petroleum; therefore it is a very different substance.

Now, I will dwell for a moment or two upon the glycerine which exists in this fat. When soap is made, an alkali is put into the oil, and the glycerine is expelled, just as when we put nitric acid into carbonate of ammonia we expel the carbonic acid gas; so that when the soapmaker puts his soda or soda lye into fat of any kind with which he makes his soap, he expels this glycerine; and this was formerly the refuse of the soapmaker. It was Chevreul, who has been called the "Father of the fatty acids," who first pointed out its true nature and composition, and that it differed materially from stearic acid and the other fatty acids. Its composition is—

Carbon.......	36
Hydrogen	7
Oxygen	40
	83

besides a quantity of water. And now you see how this glycerine is composed, as contrasted with the other substances in fat. Stearic acid is composed as follows :—

Carbon........	204
Hydrogen	33
Oxygen	24

The oxygen is in much smaller quantity than in glycerine. In the glycerine, the oxygen combines with the hydrogen, preventing the combustion. This, then, is the substance got rid of in soap-making. In order, however, to obtain stearic acid for candle-making, the oil is decomposed by steam. This beautiful process was discovered by Mr. G. F. Wilson, and the oil is thus decomposed for the purpose of obtaining stearic acid for candle-making.

The following extract from a paper read by Mr. Wilson before the Society of Arts gives an account of this process:—

"I will now proceed to describe the new process for obtaining and purifying glycerine, and may remark that the road by which we arrived at pure glycerine was a rather circuitous one. Our first step was to do away with the lime process of saponification, and with it our only source of impure glycerine. By our first improvement in separating the fat acids from neutral fats, the glycerine was decomposed by the direct action of concentrated sulphuric acid at a high temperature; and all that remained of it was a charred precipitate. A new process for decomposing neutral fats by water under great pressure coming under our notice, led us to look again more closely into our old distilling processes; and the doing this showed, what we had often been on the brink of discovering, that glycerine might be distilled.

"In our new process the only chemical agents employed for decomposing the neutral fat, and separating its glycerine, are steam and heat; and the only agents used in purifying the glycerine thus obtained are heat and steam: thus all trouble from earthy salts or lead is escaped.

"Distillation, however, purifies the impure glycerine of the old sources.

"On the table is a series of products of palm oil, which will serve to illustrate the process. Steam, at a temperature of from 550° to 600° Fah., is introduced into a distillatory apparatus, containing a quantity of palm oil. The fatty acids take up their equivalents of *water*, and the glycerine takes up its equivalent; they then distil

over together. In the receiver the condensed glycerine, from its higher specific gravity, sinks below the fat acids. Sufficient steam must be supplied, and the temperature regulated, otherwise the elements of the glycerine do not take up their equivalent of water, and acroleine is evolved,—a body of a very different character, an acrid eye-inflaming vapour, appreciated only by those who have had the misfortune of an experimental acquaintance with it.

"In an ordinary apparatus, the glycerine distilled from the neutral fat is not in a sufficiently concentrated state for most purposes: it should therefore be concentrated, and, if discoloured, be re-distilled. It is then obtained, in the state of the specimen on the table, at the temperature of 60° Fah.: it is of s. g. 1·240, and contains 94 per cent. of anhydrous glycerine. It can be concentrated to s. g. 1·260, or to contain 98 per cent."

Glycerine, which at one time was the refuse of the soapboiler, is now applied to a variety of different purposes in the arts. It has been used by the photographer for making one of his solutions: it is also used in medicine. It is a good substitute for cod-liver oil: it may be taken in tea. Although not a good substitute for sugar, it still contains large quantities of carbon and hydrogen, and in that way may be taken instead of cod-liver oil. It has also been applied externally; and, although it is the object of the soapmaker to get rid of the glycerine, and you may laugh at him for putting it back, yet the glycerine soap is made by the addition of a quantity of glycerine after it has been manufactured; and, as an external application to the skin, it prevents chapping, and preserves the epidermis, and is very valuable in the winter season, on that account. It is used also to preserve animal matter. Fish have been preserved, I believe, in this glycerine for seven or eight years, and they have perfectly retained their colour and their freshness. It

has been recommended on this account as a preserver of food, which, when kept in it, is free from any taste. The glycerine is soluble in water, and has none of the stickiness of oil, and food may be used with impunity after being kept in it for any length of time. Then it has been used extensively by perfumers; it is used as a cosmetic with carmine, and being rubbed on to the face, gives the colour that youth and health ought to have. There are, no doubt, many other uses to which this beautiful substance may be applied when its properties have come to be more thoroughly understood.

With regard to the sources of oil, the following notes from the Catalogue of the Animal Products at South Kensington Museum will give you some idea :—

"The fat of birds is sought after in many quarters, and esteemed for various purposes, culinary, medicinal, or manufacturing. Goose-grease is considered an emollient or healing application for chapped hands. Peacocks' fat is valued in Travancore and other parts of India.

"An oil of a deep red colour is obtained by pressure from the stomach of the young sooty petrel (*Puffinus brevicaudus*), known in Tasmania as the mutton-bird. It is said to possess virtue as a liniment in rheumatism, and it burns with a clear bright light.

"The guacharo (*Steatomis caripensis*).—This curious nocturnal bird, which is about the size of a common fowl, inhabits immense caves in some parts of South America, and is much sought after for the great quantity of oil which is rendered by the fat of its body. Humboldt gives an interesting description of the slaughter of them in one of the large caverns of the Guacharo mountains, in about 10° 10′; whence it takes its name. Once a year, near midsummer, this cavern is entered by the Indians, armed with long poles, who ransack the nests for the young birds, which are opened as they fall down. The peritoneum is found loaded with fat, and a layer of the same substance reaches from the *abdomen* to the vent, forming a kind of cushion between the bird's

legs The fat thus obtained is melted in clay pots over a brushwood fire, and is called butter or oil of the guacharo. It is half-liquid, transparent, inodorous, and so pure that it will keep a year without turning rancid.

"Emu oil is stated to be a very successful restorative in cases of rheumatism. The fat of the emu will, if properly boiled, produce about two gallons of oil. It is supposed that this bird, being deprived of wings, is endowed with a larger quantity of oil to give the muscles freer play, and enable it to move along with necessary facility.

"Fish oils are obtained from a variety of sources: a large quantity is procured in the East from the liver of the white shark.

"Train oil is the general name for the common fish oils, whether obtained from the whale, seal, pilchard, or other fish. It is used by leather-dressers, soap-boilers, for burning and other purposes.

"At one time we prosecuted the whale-fishery with great success; but our merchants seem to have abandoned the enterprise in a great measure to the Americans, who, in the North Pacific, find it one of the most lucrative branches of business now carried on, looking especially at the high and rising price of oil. The Americans have, at the present time, 655 vessels, registering 204,209 tons, employed in the whale-fishery; and the vessels of their Pacific fleet have averaged, for the past five years, more than 1,000 barrels of oil to each ship.

"Under the general name of black-fish oil, several kinds of oil are included. Thus the South-Sea whale is called the black-fish, the pilot-whale (*Globiocephalus Svineval*) is known as the black whale to seamen, and among American sailors the *G. intermedius* is so termed. The common black whale of the Australian seas is *Balæna australis*, and the name is sometimes applied to the *Physeter microps* and the *Physeter Tursio*. The killer or black-fish of the South-Sea whalers is the *Globiocephalus macrorhynchus*. A black-fish of average size will produce from 30 to 35 gallons of oil, which, in its most recent state, has a dark colour and an unpleasant odour.

"The preparation of fish oil is carried on, on the Indian coasts, on a large scale for export to England, and the demand is yearly increasing. Fish-liver oil is prepared at Madras and the west coast of the peninsula.

"In a commercial point of view, the preparation of cod-liver oil is a very important branch of trade, both home and foreign.

"The mode of preparing the cod-liver oil in India is thus de-

scribed:—The proper season for preparing this oil is early in January, when the livers are plump, firm, large, white, and full of oil. The livers are sometimes found diseased, and are specifically lighter than water: these should be rejected. Good livers should cut smooth, and not tear; when cut, none of the substance should flow out in a half-liquid state.

"The quantity of oil produced by livers depends much upon the time of the year.

"In the beginning of January, 1,000 livers were found by experiment to yield 37 imperial gallons, and at the end of February an equal number only gave 23 gallons of oil. In the beginning of January, 1,000 livers of average size weighed 900 lbs., whilst on the last day of March the same number weighed only 575 lbs.

"The oil at these different seasons was equally pale, and the livers equally white, although much smaller and more flabby in the latter season.

"Seal oil is of three qualities—pale, straw, and brown. The oil from the seal is extracted partly by expression, by which the cold-drawn oil is obtained: resort is then had to boiling the blubber in large pans or caldrons. The same method and the same apparatus might be used for extracting the oil from seal-blubber as from cod livers; and when the difference in value of the oil made by the different methods is considered, it is curious it has not been carried into effect. The quantity of oil wasted partly by volatization in boiling in the caldrons, and the inferior value given to the rest by its becoming carbonized or browned, were the whole extracted by steam the advantage would be very great. The quantity of seal and fish oil annually exported from Newfoundland is about 2,750,000 gallons, worth about £320,000, besides some exported from Labrador, and oil to the value of £10,600 yearly consumed in the colony.

"The young seals not taking to the water until they are three months old, are easily killed: their skins, with fat attached, are stripped off, and the worthless carcasses are left on the ice. A majority of the vessels secure from 3,000 to 9,000: they are sorted into four qualities: young harp, young hood, old harp, and bedlamer (year-old hood), and old hood; the most productive being young harp. At St. John's, the head-quarters of the trade, the skins and blubber are separated, and the latter is put into wooden cribs, beneath which are wooden pans to catch the oil. No artificial heat is used in this process. The oil which runs for the first two or three months is pale seal oil, and forms 50 to 70 per cent. of the whole

quantity. As putrefaction takes place, the oil becomes darker and more offensive. The putrescent refuse and the clippings of the pelts yield further quantities of oil (boiled seal oil) by boiling. This old process is being superseded by a steam apparatus. By this invention a uniform and much better quality of oil is produced, free from the horrible odour of that prepared by the old method, and the time required is only twelve hours instead of six months.

"Blubber is the cellular membrane in which the oil or fat of the whale is included. Its thickness varies from 8 to 20 inches, and it yields as much frequently as 100 tons of oil from a full-grown whale. It is generally brought home from the fishing-ground packed in casks. The oil is drained out of the blubber by placing the latter, cut up, on racks, through which the oil drips down into casks. It is then heated up to 225° to deprive it of its rancid smell, and also to make the grosser parts settle. The oil is then pumped over with water, left to cool, and finally stored in casks."

I will now direct your attention more particularly to the nature of soap. I have before explained the theory of its formation. The substance which we call soap is a salt. We take stearate of glycerine or oleate of glycerine; that is to say, stearine or oleine, and add to this a quantity of soda or a quantity of potash. If we add soda, we get hard soap; if we add potash, we get soft soap. This is the process that goes on: the soda goes to the stearic acid, and forms stearate of soda; soap is then a stearate of soda or an oleate of soda. It may be made of margarine, and then it is a margarate of soda or a margarate of potash. You may put in potash instead of soda, and thus form an oleate of potash or stearate of potash, and then you have soft soap, which is also sold as shaving-soap, and Naples soap.

Then we have two sorts of soap formed; the one soluble and the other insoluble. Now, I need not tell you that it would not do to use insoluble soap.

We all know diachylon plaster; this is an insoluble soap. If you look into the Pharmacopœia of the London College of Physicians, you will see that diachylon plaster is made of lead and oil. The lead does just the same as the soda or the potash did; it goes to the oleic acid, and forms oleate of lead; but it is insoluble in water, and therefore we cannot use it for washing. Another insoluble soap is that which is formed with lime. If you take soluble soap and use it with hard water, the soap seems to stick about your hands, and you may think that you can wash a good deal better without the soap than with it. Why?—Because you have got, instead of the soda, lime. We were not using oil in this case, but oleate of soda; and when we add this to the lime, we see what takes place. The lime goes to the oleic acid, and the soda is lost, and the insoluble lime-soap sticks to your hands, just as if you were washing in water containing acetate of lead; and that is what makes hard water expensive, for you keep on washing and rubbing until you get rid of the lime, and then you can go on. I should advise those who are compelled to use hard water to employ soft soap.

The materials used for making our hard soluble soaps are soda and a variety of fatty matters. It would take me much too long to go into anything like detail on the nature of these fatty matters; but I may just say that the coarsest kinds of fat—the kitchen-grease, the grease boiled out of mutton-bones, collected from the kitchens of London, are combined with soda for the purpose of making soap. Curd soap is one of the best kinds of washing-soap, and is made

generally from palm-oil, which makes a better soap than any of the other kinds of oil. At the same time these soaps—the mottled soap, the brown soap, and other kinds—are made of coarser materials than palm-oil; they are made of coarser fats, and to these fats is constantly added a substance which we know by the name of resin. Resin is a product not unlike oils, containing an acid which combines with the soda, and forming a soluble soap, in the same manner that the fat does; so that the resin, as it were, assists in the production of the soap, and is added to the brown soaps, whilst the mottled soaps are made with the coarser kinds of kitchen fat. Now, there are other kinds of soap which have been introduced of late years, and which are supposed to have been manufactured in different ways; but I may say that there is no other way of making soap than by the addition of alkali to the fat, and getting rid of the glycerine; and, therefore, these names are given for the purpose of indicating something that has been introduced. Thus, we find that all kinds of scented soaps are made by the introduction of various volatile oils during the manufacture of the soap. These soaps are put into moulds, and made to assume a variety of shapes. Thus we have fancy soaps, of which there are numberless forms, and which are generally curd soap reboiled and recast. There are also medicated soaps. You may purchase iodine soap and creosote soap, and I do not know whether you could not have any kind of soap you wished; but it is always one of the simple kinds of soap reboiled down and mixed with the special ingredient.

With regard to the soft soaps, they are not so pleasant

to the skin; but potash is a more vigorous detergent than soda; where you want a strong lather, it is very desirable to use strong soap, and gentlemen with strong beards, who do not choose to let them grow in the present day, as the fashion is, find it necessary to use soft soap. Naples soap is a potash soap, and is made in Naples from fish oil.

Now, why do we use soap at all? What is the good of it? After all I have said, I fancy it will puzzle you to tell. We know that we wash with it. But how does it act upon our dirty skins, or linen, or boards, that we should use it in such enormous quantities. Liebig says that the quantity of soap used in a country is a test of civilization; and it is happy for you Britons to know that you use more soap than any other people in the world. At the same time, you know, no one will say we use as much soap as we ought. Well, with regard to its action; in the first place, it dissolves in water, and that is one of its qualities. Again, this solution of stearate of soda has a property of holding in solution oil—of making that soluble which, while on our hands, is insoluble. You rub on a little of this detergent substance, and the oil is dissolved by it, and both are dissolved in the water. The oil on our skin entangles the little particles of carbon, and a thousand things to which we are exposed in the air, especially our faces and hands, and in this way the skin gets soiled, and it is by the removing this oil and its impurities the soap acts as a detergent. But we may add more alkali to the soap, so as to secure the action of the free alkali, and that is what we do in washing. The washerwoman *adds soda*, so that she makes extra soap. So with the

clothmaker; he adds soda and potash lye to the cloth for the purpose of taking away oil; so that you see the soap acts in two ways; first, by washing away the oil, and next by saponifying the oil. In soaping the skin, we should remember that the alkali will not only dissolve the oil on our skins, but will actually dissolve the little epidermal scales of which we have before spoken, and this will chap the hands and roughen the face; and the consequence is, that by being desirous of cleaning the skin too well, we, on the contrary, roughen the skin, and that renders it more liable to contract dirt. This is the result of using highly alkaline soap. Brown soap, for instance, contains a greater quantity of alkali than curd soap; but the harder the soap the better it is. It requires patience, but in the end it will be seen to serve the purposes of washing better. This is a hint for those who wish to have very nice, clean, white-looking hands.

Now, I must leave soap, and draw your attention for a little while to the manufacture of candles. The use of fat or of fatty matters for the purposes of combustion is very ancient, and we read in all past history that man has employed these fatty compounds of hydrogen and carbon for the purposes of combustion. Wood contains carbon and hydrogen; coal contains carbon and hydrogen. We have no blaze without hydrogen, and we have no solid heat-giving substances without carbon. In all these instances we can easily obtain proofs of the burning of carbon and hydrogen in contact with the atmosphere. Let any one try the experiment. It does not signify whether you take a lamp, a candle, or a gas-light. Cover it with a

glass vessel, and a quantity of vapour will condense in it; presently the light will go out, from the fact that the oxygen is exhausted, and a quantity of carbonic acid gas formed. Now, in this way you get plenty of evidence of the existence of water, as condensed in the inside of the bottle; and if you add a little lime-water, you will prove there is carbonic acid gas, for you will find the water become milky from the presence of carbonate of lime. This is the philosophy of combustion everywhere,—of the great combustion which goes on in our manufactories, our fireplaces, and candles, and lamps, and of the combustion which goes on in our own lungs. In the latter case, we take the fat for breakfast and dinner, and we take in the oxygen by our lungs, and throw off carbonic acid gas.

Formerly tallow candles were used. That was the highest perfection of illumination at the beginning of the present century; they required snuffing, and burnt very feebly compared with more modern candles.—Why? Because in the tallow candle we burn stearic acid and glycerine. It is the latter substance which prevents a more perfect combustion; and, further, if you blow out the lighted tallow candle in the kitchen, the smell becomes very unpleasant, even in the attics—so unpleasant, that if you are asleep it will wake you up. That smell is given out, not by the stearic acid, but by the glycerine. Hence you see, when Chevreul had discovered that glycerine was the base of all these fats and tallows, he put the candlemaker in the way of getting rid of the substance which was most objectionable in the tallow candles—at the same time he never *succeeded* as a candlemaker; I believe he tried in

Paris some twenty years ago, but failed altogether. It was left for practical Frenchmen, and still more practical Englishmen, to realize the benefits of all his discoveries. The improved candles used in the present day, are all the result of this discovery. The tallow candles are made by taking a quantity of cotton and dipping it into the hot tallow, and redipping it again and again till the candle is made; hence they are called "dips:" but the mould candle differs in being made in moulds or tubes, which are filled with the tallow, instead of being dipped; they burn better than dips. The aggregate weight of tallow candles, dips and moulds, turned out in the United Kingdom, is known to be about 1,000 tons weekly, or 52,000 tons per annum; and the general wholesale price being now about £60 per ton, shows the value of the manufacture to be £3,120,000.

Stearic acid candles are the candles which contain the fatty acid alone, and they burn best; however, when you deprive the candles of glycerine, you have made a candle that is very expensive, and this becomes a matter of serious importance. It was, however, left to Mr. J. P. Wilson to invent a candle, now called a composite candle, which consists partly of cocoa-nut stearine and partly of stearic acid, and which does not require snuffing, and gives out but little scent when blown out. It is these cheap, good candles which are sold in such large quantities in this country, not manufactured by Price's Company alone, but by every maker throughout the country.

There is another series of products made by Price's Candle Company, consisting of candles known by the

name of night-lights, which are interesting things, as constituting a manufactory in which a very large number of children are employed. The process of manufacture is very simple: pieces of wood are planed and split into thin layers, and rolled up into the form of a box; this is then handed on to a boy, who inserts a piece of wick, and then it is handed on to another who puts in the fat; and in the course of a very few minutes, the night-light is made. There are hundreds of little hands employed in this way, and in the course of a day several thousands of these night-lights are made, which are exceedingly useful when only a small quantity of light is required. You may have night-lights made to burn any number of hours, and of any size. I saw a number of night-lights which had been made for gardening purposes, and they were used for placing under a glass case in which plants were, and which required a higher temperature than our atmosphere. By the aid of these little lights, people might hatch their own chickens, by placing the eggs in sand, and raising the temperature to the point at which the chickens are hatched.

There is one substance that comes in competition with fats and oils for making candles, and that is spermaceti. Spermaceti is not fat, but it is very like it. Instead of glycerine, we have an oxide of cetyle; and it is not now worth explaining the difference in the nature of these substances. Now, where does spermaceti come from? Why, from the head of the great whale—the *Physeter macrocephalus*. This whale, which is remarkable for the large size of its head (Fig. 1), *is found* in almost all seas, but is now most frequent in

the Southern Ocean, on the coasts of America, Japan, Lima, and New Guinea. It is one of the largest of living animals, and attains a length of eighty or ninety feet. Of this length the head occupies a third. In the head is a cavity called a case, in which is deposited the spermaceti. The head of a single whale has been known to contain as much as a ton, or ten barrels, of the oil and spermaceti. This oily matter is lighter than water, and thus the animal is enabled to float easily in the water, in spite of its great bulk, and to lift out its great head for the purpose of breathing. This process is called the spouting of the whale, as during expiration it throws out the air, mingled with particles of water, so that the stream of air can be seen like a spout. These whales are generally gregarious, and hundreds of them are often seen together, forming what is called a "school." The larger males, however, feed alone, and are then easily approached and caught. When the animal is captured, the spermaceti is taken and compressed, and separated from the sperm oil, and afterwards bleached; and then you get the beautiful white substance called spermaceti. It is easily melted and poured into moulds, and then it makes candles, which burn as well as tallow candles. They are more elegant, give as much light, and do not smell, and they are really worth the money they cost as compared with tallow. Many thousands of tons of spermaceti are brought into this country in the course of a single year, and manufactured into candles. The candle-manufacturers thought, when gas was introduced, that they must get ruined; and then the spermcandle-maker, when the

improved oil candles were introduced, thought he should get ruined. But the people of this country still burn sperm candles in preference to others Thus it is with men engaged in business. The papermakers and the winesellers, now that the duties are going to be reduced, fear they are going to be ruined; but so far from what they anticipate being realized, new discoveries and lower prices always lead to increased demand, increased energy, increased business, and in the end increased competition and benefit to society.

Now, spermaceti has some other uses besides that of burning. It is mixed with yolk of egg, and made into a very pleasant mixture for colds and coughs. Sperm oil is extensively used in our large manufacturing towns. It is employed for the purpose of diminishing the friction of those wheels which are daily producing so many of the necessary comforts of our life. Not only sperm oil but palm oil, and all oils, are used for diminishing this friction, by which we are enabled to work the wheels of our machinery, to spin and to weave, to travel quickly on railroads, and to pass rapidly over the broad ocean. The diminution of friction by oil is one of the great elements of our civilization; that is another reason why we are so anxious to get these oils from all parts of the world. The fats of this country are insufficient for its exigencies, and, therefore, the fat of the horses of the Pampas of America, and of the bears of the Arctic regions, and the oxen and sheep of Africa, and the oils of the palm-trees of Africa and Asia, are brought into this country in immense quantities.

In the application and uses of fats and oils we have a wonderful instance of how a knowledge of the nature of a substance increases man's power of using it and applying it to the purposes of his life. The same results await his discoveries in every direction. It is by these discoveries that he is raised in the scale of civilization, and becomes more and more the master of the world in which he lives. Yet it is precisely these very studies that he systematically neglects. Up to this moment, in this country, neither the Government nor the people have made any systematic attempt to teach the principles of the sciences on which our whole national industry depends; nay, every attempt to do so is treated with more or less of ridicule and contempt, and we are told that the multiplication of words for a fact, and a knowledge of figures that represent nought but mental abstractions, are the only training necessary to fit man to enter on the career of life. Surely the accumulating evidence that man advances only as he knows and applies the laws by which God governs the world in which he lives, will at last open the eyes of the people of this great nation to the necessity of teaching every one who is born into this world all that he can know of the uses and reasons of his existence.

ON WASTE.

"*Gather up the fragments—let nothing be lost,*" is a divine injunction for us in every age. We recognize it most strictly, I hope, with regard to our food, but, perhaps, we are not so particular with regard to the fragments that are likely to be lost in our manufacturing operations. If we look abroad upon the world, and see how God is governing the universe—see how he is correlating the powers of nature and the properties of matter, we shall see, there, indeed, that nothing is lost; we shall find that no force ever assumed by an atom of matter is wasted. Matter is perpetually changing its forms, but whilst changing its forms it is ever subserving some use in nature. Man should study these laws, and examine the works of the

hand and the finger of the great Creator in the external world, and try to imitate him. It is man's privilege to be created in the image of his Creator; it is his privilege to follow in the footsteps of his Creator. He is placed here the monarch of the world, and it is only as he fails to understand his duties in attaining a knowledge of the laws of the external world, that he suffers pains and penalties. I want to show you that if we imitate in our manufacturing processes the great laws of nature, we shall save much, and we shall also diminish our labour and multiply our sources of happiness on the earth. We can see it in some things more obviously than in others. We can see it in the mineral world. When the workman is at work on the diamond, he suffers not a grain of its dust to be lost or wasted, but hoards it up for future use. So with the workmen in gold and silver. We find that the particles of dust that escape in various directions are carefully collected;—and it is not less true with regard to vegetable products. We see the shavings and sawdust of the carpenter and cabinet-maker carefully collected together for other purposes and uses in the arts and manufacturing operations; and it ought to be no less so in the animal kingdom, in the use of the animal products. With this view, I propose to-night to see whether there have not been some fragments thrown away in the manufacturing operations we have spoken of, that we may point out how that which is now lost may be saved.

There is an anecdote told of a distinguished chemist, who was asked how he had made his great discoveries, and he replied that it was by examining that which

other chemists threw away. So many a manufacturer may make his fortune by using that which others throw away.

In the first instance I will call your attention to the chemical, physical, and general properties of the materials of which we have been speaking. We spoke of these to some extent in the first Lecture; we saw that the animal tissues possessed certain properties which made them valuable in the arts, and we found that these substances were formed of certain chemical elements which exhibited definite chemical properties; and we shall see that a result of this study is a knowledge of the application to the arts of life of these substances which would otherwise be lost and thrown away.

I purpose first to examine some of the substances which, on account of their physical properties, are now recovered, and which at one time were regarded as waste. I spoke to you first of silk, and I referred to the way in which the silk is wound off the cocoons, and how it is rolled and afterwards spun, and formed into a variety of garments.

During the operation of spinning there is a quantity of loose silk, which would be entirely lost but that pains are taken to collect it in a rough state; it is then pulled out, and the fibres again reeled, and it is manufactured into the lower kinds of silk. The waste of this process is collected again, and again it is re-reeled and wound; so that not a fibre is lost. After the silk of the cocoons has been wound off, there still remains a quantity of silk upon the used cocoon, which, under the name of "knubs and husks," is imported into this

country. The knubs and husks are torn to pieces, and the fibre is reeled and woven into the lower sorts of silks; so that there ought to be no waste in silk at all. I told you, I think, that the Chinese even eat the grub within the cocoon.

I pass on from silk to wool. During the process of spinning and weaving wool, there is a quantity of waste —a quantity of the hair is left; but this is now collected, and applied in a variety of ways. Some of the better kinds of this waste wool can be used and mixed with higher sorts, and are thus worked up. We find that, after the cloth is woven, the ends are cut off, under the name of *list*, which is again torn to pieces and re-wound. There is also from such waste portions an extensive manufacture carried on of the substance known by the name of flock. The wool is ground down to a powder, and mixed with colouring matters, such as vermilion for red, chromate of lead for yellow, arsenite of copper for green; so that the flocks assume a variety of colours; and these coloured flocks are used for the purpose of manufacturing what are called flock-papers. The paper is figured in a variety of ways, and the figures are covered over with size or gum, and the flock is powdered over it: it is then called flock-paper. This process was first patented by a Frenchman named Jerome Lanyer, in 1634, and since his time there has been a considerable manufacture of flock-papers in this country. It has, however, reached great perfection on the continent, and the French have paid particular attention to the patterns. These flocks, then, have been produced by the refuse of the woollen manufacture.

I would here say one word with regard to the

colouring matters of flock-papers, as it is a matter of importance. They should not be mixed with poisonous substances. The greens are mostly made with arsenite of copper; and instances have not been rare of persons living in rooms where these green flock-papers have been used; and the consequence has been, that when the paper has been brushed, the particles of arsenite of copper have got into the air, have been taken into the lungs, and produced injurious effects on the system. I do not know that it is so deadly a thing as represented, but it seems an imprudent thing for people to live in rooms covered with these green papers. Wherever these flock-papers are used, they accumulate a greater quantity of dust than other papers, and consequently require to be brushed oftener. It is undoubtedly much the most wise and prudent plan in the case of paint, and in the case of all substances employed in rooms where persons live, that they should not contain poison.

This arsenite of copper has been the source of a variety of suffering in many directions. It is sometimes used to colour confectionery, and I have known children killed by it. The green fields and green trees looking so pretty, with the white sheep feeding on the top of twelfth-cakes, have been known to contain arsenite of copper. I recollect a case of a number of people being poisoned at a dinner-party by eating some nice green *blanc mange*, which had been coloured with arsenite of copper. With yellow orpiment, a sulphide of arsenic, some boys were recently poisoned by eating Bath buns made yellow by this substance.

Now let me draw your attention to the fact that the wool, after it has been used—after it has been worn, has

its analogue in the rags of linen and cotton clothing. You know how desperate has been the condition of the paper manufacturer because he cannot get a supply of rags for his manufacture. The woollen manufacturer has been saved from the same state by a material which is produced under the name of "shoddy," and which is extensively used in the manufacture of clothing of common quality, such as pilot-coats, ladies' mantles, druggets, and the cheaper kinds of carpeting. This material is not made of new wool, but of wool that has been worn and afterwards torn to pieces by machinery. This shoddy has various prices in the market, according to the substances from which it comes, and you will find the specimens of the material under various names, such as "black and grey army clippings." I suppose they are the torn-up clothes of soldiers, who, probably, have been in the field of battle, and having come back, have sold their clothes second-hand. Then we have "seamed middle white." I do not know what kind of cloth that has been. Then "scarlet cloth." Then there is "Hamburg blue-stocking shoddy," and shoddy from "black stuffs," from "brown stuffs," from "white serge," from "druggets," and "carpets." I mention these names to show you what a variety of substances are thus torn up, and made again into new cloth. Some forms of this shoddy are called "mungo." Thus we have "blue mungo," "brown mungo," "grey mungo," "claret and white mungos;" and there are now shoddy markets, just as there are woollen markets, and the shoddy markets are increasing every day. One principal seat of this manufacture is Dewsbury, in Yorkshire. It has, however, found its way into Leeds,

Wakefield, and to all the large woollen-manufacturing towns. Those who are skilled in the knowledge of real woollen cloth can easily distinguish between it and shoddy. This trade has been sometimes objected to on account of its appearing to produce an article of a superior kind with an inferior raw material; but, after all, you will find that these shoddies are not sold at the price of superfine cloths, and are good substitutes for them. The cheap clothing of late years has depended upon the introduction of this shoddy, and, provided the price is not larger than gives the fair profit to the manufacturer, we cannot object to it, as it enables many a man to put on, at least once a week, a decent-looking coat, who otherwise would not have a cloth coat at all; and if the wear only answers to the price given, I do not think any one can find fault. However, I have heard a gentleman say he objected to stockings of shoddy, which he could not put on without putting his feet through them, and to coats that split up the first time they were put on. In this case the purchaser must judge for himself, for there is no attempt to sell them as superfine cloth,—they are sold as shoddy I introduce this subject to you to show you that it is one of the uses of waste substances. I shall show you that even after wool has been manufactured into shoddy, it has still further uses in the arts. It has recently been observed that "there is still some mill waste which cannot be used up again for 'shoddy.' It is that portion of the wool waste which is so saturated with oil and grease that the fatty matter is heavier than the wool in it: it is called 'creash.' This is one of the most powerful fertilizers. Those farmers who laid it upon

land several years ago are seeing the advantages of it every succeeding year; for it does not give out its strength to the crops all at once, though by a chemical process it could be made to yield its nourishment as speedily and be as good as guano to the enterprising agriculturist. The attention of the agricultural chemist may also be directed to the quantity of liquid manure in the soap-suds and washings, &c., which run to waste from the mills. This liquid contains the best fertilizing elements which can be found; indeed, farmers are in the habit of paying £7 a ton for substances which can do less good to their crops than despised 'soap-suds' would do."

Passing on from shoddy to leather clippings, I will mention that a patent has been recently obtained for cutting up the clippings of leather, and introducing them into the soles of boots and shoes, rendering them easier to the wearer and quite as durable; thus saving new material. Leather cuttings are also employed in the manufacture of Prussian blue. I have recently had some paper presented me by the Messrs. Schlagentweits, the celebrated German travellers, made in Berlin, from the cuttings of leather. The paper is remarkably tough, and apparently adapted for serviceable purposes; but it has not yet been used in sufficient quantity to render it a profitable manufacture.

I have hitherto been speaking of the physical properties of waste substances; but waste matters are composed of chemical elements, which can be changed into other compounds by which we can get new substances; and some of our most extensive manufactures depend on this fact. All the substances of which I

have spoken—the clippings of leather and the fibres of wool and silk,—whatever animal substances we may have, are composed of the four elements,—carbon, hydrogen, oxygen, and nitrogen. We find all these elements in carbonate of ammonia. Now the difference of these elements, as they exist in the carbonate of ammonia and as they exist in bones, or in hoofs, or in horns, or in wool, or in skin, is this—that the elements of the animal body are much more easily changed, and more readily made to assume combinations which are useful to man, than if he had to deal with mineral compounds. Hence it is that he prefers to work chemically at the gelatine or wool, or some other constituent, than to take carbonate of ammonia, which is cheap enough but not the easiest to work with.

With this view I will now speak of skin waste. The tanner has waste. While he is preparing his skins, he cuts off the fat and the portions which cover the legs and the ears. He sells all these. The oil and the fat are sold to those who boil down oils and fats of all kinds. You will recollect that the oils and fats can be made into soap; and it is no matter whether the oil or fat be obtained from skins or from other sources. Then again this oil and this fat, obtained from the tanners' waste, is made to yield its stearic acid. Its glycerine may be obtained for all the purposes to which it can be applied, and its stearic acid may be manufactured into candles. The bits of skin are carefully collected and boiled down with various other odds and ends of animal substances. The various sources from which these pieces and scraps of skin are obtained are very numerous. They are bought by the manufacturer, and

after some process of selection, they are placed in large vessels and boiled in water, and thus they are made to yield gelatine. The oil contained in those substances floats to the top. If the manufacturer wants a coarse and common tallow, it is employed as it is taken off; but if you are to have a better kind, it is afterwards prepared with great care. The water being evaporated, the gelatine is then procured. If the gelatine is to be used as size in the arts, it is less carefully prepared than if it is to be sent to your table as isinglass; and, let me tell you, whether you get the isinglass from the sounds of the sturgeon or from these things, it is all the same to you; for they are boiled down and purified, and can do no harm. Perhaps, with regard to these materials which have the same composition, from whatever source they are derived, it is best to ask as few questions as possible. The manufacturer of gelatine asks no questions, and perhaps it is prudent that you should ask none. This gelatine is certainly a very interesting substance, on account of the great variety of forms it assumes. According as it is used for one purpose or another, it is prepared carefully or not. When it is used in the arts for adhesive purposes, as in the form of glue, it need not be so destitute of colour or so carefully prepared. On the continent it is now manufactured into all kinds of forms. Large sheets are made for the purpose of colouring glass, for cutting up and forming into artificial flowers. It is used for the internal decoration of rooms, and for the wrappings of sweetmeats. Those who are in the habit of cracking *bonbons* at the supper-table will recollect that they are wrapped up in this coloured gelatine. This manufac-

ture is entirely dependent upon the use of what was a few years ago regarded as waste material.

I now come to the waste in bones. I mentioned that buttons were made of bones, and handles of knives, and a variety of useful articles, are made of bones. The buttons are punched out of the bones, and the pieces that are left are not lost. The dust made in sawing bones is collected; and butcher's bones and household bones are all used. They are first boiled down, and the fat is taken off, as in the case of the skin, and then their gelatine is dissolved, and the gelatine is used for glue, or size, or isinglass. In the bone that is left, there is still useful material, which may be employed for various purposes. The refuse of the bone-boiler is now commonly introduced into a closed furnace, by which a peculiar kind of animal charcoal is produced. So you see that after they have made buttons they are used for making size, gelatine, jelly, soap, and candles, and then they are still available for making animal charcoal. This charcoal, for many things, is better than any other; and this raises the question why this is the best? There is another form of animal charcoal obtained from burning blood, and which may be considered the best animal charcoal, because it contains the largest quantity of carbon; but it is found that this bone charcoal is better for filtering purposes than the ordinary animal charcoal, and at this moment it is fetching a higher price in the market. It is used especially for filtering water and refining sugar. You know that sugar is brought into this country in a brown state. Here it is melted and purified by passing through animal charcoal. One filtration is not sufficient, but a second is; and the

charcoal which is found to be most efficient is this charcoal which is made from the refuse of bones after all the gelatine and fat have been extracted. It is probably, then, not so much the carbon which strains and keeps out this organic matter, as the phosphate of lime. Now, I do not mean to say that any one would make a fortune by it, but it is worth consideration whether common vegetable charcoal mixed with phosphate of lime may not answer as well. Here, perhaps, we may inquire how it is that these charcoals act as purifying agents. I may say that this purifying action is not confined to water and sugar, but that chemists use animal charcoal as a means of purification for a variety of processes. It would seem, with regard to the water, that the animal charcoal has a power of absorbing and holding, and, as it were, introducing oxygen to the impure substances contained in the water, so that they become oxidized and converted into something else; for we find that the animal charcoal retains its power of purification for several years. If, instead of oxidizing these substances and passing them through, it acted as a strainer or sieve, straining out the impure materials, then you would have the charcoal blocked up; but it is not so. These impure substances in water are all composed of carbon, hydrogen, and nitrogen. The oxygen oxidizes the carbon, and forms carbonic acid gas, which makes the water sparkling and refreshing. It oxidizes hydrogen, and converts it into water: it oxidizes nitrogen, and converts it into nitric acid. One of the impure-smelling substances in water is sulphur, and the oxygen unites with it; and thus we get sulphuric acid, or sulphates. Thus the impurities

of the water are converted into substances which may be consumed without any injury whatever.

This, I think you will say, is a most remarkable instance of the application of waste to important purposes. This has really arisen out of the necessities of the bone-boilers, who, when they had obtained the fat and gelatine out of the bones, left them to accumulate and engender and send forth a smell of sulphur and ammonia, and other compounds, which made people object to the annoyance of bone-boiling houses near to them; and now, instead of allowing these bones to lie and produce these ammoniacal compounds, they are at once thrust into a furnace, and converted into charcoal. Now, these things encourage us to go on. Let us not be beaten by bad smells. All these substances which throw out disagreeable odours—all these may be conquered and made to serve our highest and best purposes in life. The very sewers' smells, which are so injurious in the summer season of the year in this metropolis, even these may be made to form compounds with other substances, which, being conveyed on to the land, actually fertilize it; and the compounds of carbon, oxygen, hydrogen, and nitrogen of the sewers become the compounds which feed us in "our daily bread."

Then, suppose you had used your animal charcoal, and that it had become blocked up, what are you now to do with it? You cannot reburn it: but although it will not bear that process, it still contains phosphate of lime; it still contains that precious constituent which forms part of our bones, and the bones of the lower creatures. We must have that in our system, and where are we to get it from? The bread which we eat

from day to day must have it. And where is the bread to get it from? Why, from the land on which it grows. If the land will not grow wheat, and the meadows grass, they must be made to do so. The soil may become exhausted, and has again and again been exhausted. We have instances of farms which have ceased to grow wheat because they have no more phosphate of lime. There are meadows which fail to grow grass because of the want of this phosphate. Then how can the farmer remedy this? In no way but by applying the phosphate to the soil; and this he may do by applying to his land the refuse of our great cities. But we may throw away our phosphate, we may pour it into our sewers and rivers, and thus destroy it, whilst our crops are exhausting our fields;—and this is the history of the great empires of antiquity. Why have they ceased to exist? History will give you a variety of reasons why they have sunk. Some will tell you that it was because of their immorality, and others because of their civilization. But you will find around the great cities of antiquity, of Africa, of Asia, and of Europe, that the soils have become exhausted of their phosphate of lime, and consequently their crops have failed. Man could not then bring his food from great distances, and he has been compelled to seek his food on unexhausted soils. On this account the great cities of antiquity have been depopulated, and new colonies have sprung up in every part of the world. But modern chemistry has shown man how he can avoid this necessity. It has pointed out that we have in these decaying bones the material of future life: it has shown us that in the earth are the bones of extinct animals containing this

precious phosphate of lime. Thus we now bring up these creatures of a pristine world, and throw their ashes on our land to fertilize our fields. In the form of coprolites and phosphatite, we now get this phosphate of lime from the green sand of Cambridge, the red crag of Suffolk, the lias of Gloucestershire, the weald of Sussex and the Isle of Wight. This phosphate, in a mineral form, has also been found in Estremadura, in Spain, that country of never-ending wealth. There it exists in thousands, tens of thousands, probably millions of tons; although Spain has not yet arrived at a knowledge of the importance of this substance, and sends little or none into the markets of Europe. We get it, however, from Sweden and Norway, and other parts of the world. And here we have an instance of the use of that which previously had no value, being made subservient to the highest purposes in the life of man.

The dust of bones and ivory is sold in the shops, and used for various purposes. Ivory filings are collected most carefully by the ivory-turner, and sold as ivory-dust. Jellies are made from ivory-dust, and they are supposed to be more nutritious than jellies made from other things. I have, however, told you, in previous lectures, that gelatine is not nutritious. However, we have in this ivory-dust phosphate of lime, and it may be that a portion of the phosphate is thus introduced into the system. Then, bone-shavings are used as a substitute for ivory-dust, and are employed for the purpose of making a jelly which is frequently administered to the sick. Ivory-dust and bone-shavings are also employed for making a size.

Passing the refuse of leather, skin, bone, and ivory

manufactures, I come to a curious instance of the application of refuse to purposes in the arts. If you recollect what I said more particularly with regard to the preparation of cloth, you will remember that I stated that soap was frequently employed for the purpose of washing away the oil and other impurities in the wool. Now, this soap is used in such large quantities, that soap-suds have become a source of annoyance in the rivers in cloth-manufacturing towns; and it has occurred to chemists, that if the materials of the soap could be collected, they are of considerable value; and in some places there are arrangements made for arresting the suds, which contain both potash and oil in large quantities. When collected, sulphuric acid is added to the suds, and the soap is thus decomposed; the potash and the soda go to the sulphuric acid, whilst the fatty matter floats on the top; and in this way large quantities of useful matter are rescued from destruction in our manufactories. The fatty matter which rises to the top of these soap-suds is skimmed off and made into soap again, or into candles, or converted into other products in which fat is used. I do not know whether, in our domestic arrangements, it would be economical to keep a bottle of oil of vitriol, to enable us to skim off the fat from our soap-suds, but, at any rate, it is an interesting application of refuse, and ought not to be lost sight of.

Now, let me call your attention to another process. The fragments of woollen clothing, bone drillings, whalebone shavings, hoofs and horns, button-makers' refuse, horn-shavings, dried blood, woollen waste, all sorts of animal products, the sweepings of manufactories, the

lost atoms, which could not be used or employed for anything else in the respective manufactories, are used for making crystalline salts, known by the name of *prussiates*. There are two of these prussiates generally known; one is a beautiful yellow salt,—the other is an equally beautiful red salt.

And what are these prussiates? It is just worth while studying them for a moment, to see what curious compounds result from animal chemistry. The word prussiate comes from prussic acid (which comes from Prussian blue), which is also called hydrocyanic acid, and which is composed of hydrogen and cyanogen, and the latter is a compound of carbon and nitrogen. Old scraps of iron are collected together, and with potash and animal matter form these prussiates.

In order, then, to obtain these salts, we take three sets of substances:—1. Refuse of animal substances—blood, bones, hoofs, horns, &c., which yield nitrogen and carbon. 2. Old scraps of iron,—refuse iron, shoes from dead horses, rusty nails, and worn-out iron hoofs. 3. Potashes, Montreal ashes, the refuse, if you like, of hewn trees; and these supply the potassium. Now, when these things are exposed to heat together, they arrange themselves in this way:—the iron unites with the carbon and nitrogen in the form of cyanogen, forming ferro-cyanogen, and this compound unites with the potassium, forming the ferro-cyanide of potassium; and this is what these salts are—ferro-cyanides.

I will not go further into the history of these prussiates, but just say a few words about their use. I do not know that there is any use for this prussiate of

potash alone; but let us see how it acts in combination with iron. There are two proportions of cyanogen, and two proportions of potassium, and one of iron. Now, if we take a solution of iron and add it to a solution of this yellow salt—this prussiate of potash—it will be converted into a beautiful blue substance. This is Prussian blue—Berlin blue; and it is the base of all the blues that are known by that name, and the base of many other colours also. What is this Prussian blue? Why, it is a ferro-cyanide of iron. We displace the potassium by the addition of the iron, and thus form this important dyeing material. This is obtained, then, from waste made up of the sweepings of our manufactories, the refuse of our slaughter-houses, and blood and filth of all kinds. Man comes in, you see, as creator, builds up the elements, and makes all these beautiful colours with which he dyes his silk, and makes blues for his calicoes and other materials. The Prussian blue is also mixed with flocks, and is used as a pigment, being extensively employed wherever a blue colour is an object.

Now, there are many other things which I might speak of in connection with this large subject. I might show you that some materials which look unlikely to be employed in the arts for any useful purposes, have been employed in that way. Recently there has been an attempt to use the substance which we know by the name of guano. We bring it over to this country on account of the phosphates which it contains. A series of beautiful colours have been obtained from this guano. If we take a little of it and mix it with nitric acid, we shall find that it will produce the beautiful

colour of murexide. In the South Kensington Museum there is a series of colours which have been manufactured from guano. A few years ago, the test of the action of nitric acid upon the substances contained in guano was merely an amusement or chemical test: nobody ever thought of using it in the arts. But now, these substances are manufactured in large quantities, and guano is used successfully in the arts.

These beautiful colours do not, however, depend on the phosphates of the guano, but upon the lithate of ammonia. When we add nitric acid to this substance, the purpurate of ammonia, or murexide, is produced. According to the way in which the guano is heated, will be the variety of results obtained. This is just one of a hundred applications of chemical knowledge to substances having a similar nature to guano.

I was asked the other day whether I had ever seen the colouring matter produced from an insect (*Cimex lectularius*) uncommonly disliked in this country. Some one in Australia, it was stated, had taken out a patent for procuring a beautiful colouring substance from this little creature. And if this should be the case, there is no doubt that they would run the hazard of extermination. I do not know whether this process has succeeded, but it illustrates the fact that there are hundreds of common things around us which may be made useful by the application of industry and intelligence.

Speaking of insects and their products, I must here remind you that to the insect tribe we are indebted for chloroform—one of the most powerful agents in alleviating human pain. The little ant contains a

substance called formic acid, about which old John Ray and Martin Lister corresponded a century ago; and they found that it contained an acid; and so it got into books as formic acid. It was found to be composed of a compound radical, formyle, and three atoms of oxygen. Dumas substituted chlorine for the oxygen, and thus obtained terchloride of formyle, which is chloroform. Then the Americans found that ether was capable of taking away all sensation from the human body; and Dr. Simpson, of Edinburgh, found that terchloride of formyle was more thoroughly adapted for this purpose than even ether. All this has arisen from a study of the habits of insects. There is no telling but that every insect has some use in relation to man. Such facts are inducements to study. Be not dismayed by obtaining no immediate results. Surely it is some reward, even if we do not get a money payment, to feel that we have not lived in vain; that we have exerted our brains to the utmost to fulfil the mission that God sent us to perform on this earth; and that we have left the world wiser and better for our work in it. But you may be assured some people will get the money. You and I are the better for rich men. These large capitalists are not keeping the money in their pockets: they are spending it in a variety of ways. It is the wildest of theories to think rich men are an injury to the poor: they better the poor man. Then let us help the men to get rich, seeing that they cannot deprive us of the blessings of intellectual research and exertion.

But here I must cease my illustrations from the insect kingdom. The subject is a large one, and I

hope some day again to bring it before you. I have before said there is no part of an animal which is not of use. So when they are dead, they ought not to be buried or cast away. I wish here to illustrate the whole subject of the uses of dead animals by this diagram, drawn up by Dr. Playfair, which gives you the value and uses of a dead horse. The value is not a large

Value of a Dead Horse from 20*s.* *to* 60*s.*; *Average Value,* 40*s.*
Weight in Pounds, from 672 *to* 1,138; *Average Weight in Pounds,* 950.

—	Weight.	Value.	Uses.
	lbs.		
Hair	1½	8*d.* to 1*s.* per lb.	Hair-cloth, mattresses, plumes, and bags for crushing seed in oil-mills.
Hide	30	About 8*s.*	Leather.
Tendons	6	—	Glue and gelatine.
Flesh	Boiled 224	1*l.* 8*s.*	Meat for men, dogs, and poultry.
Blood	60	—	Prussiate of potash and manures.
Heart and Tongue	—	—	A mystery.
Intestines	80	—	Covering sausages and the like.
Fat	20	3*s.* 4*d.*	Used for lamps after distillation.
Bones	160	4*s.* 6*d.* per cwt.	Knife handles, phosphorus, super-phosphate of lime, bone-dust.
Hoofs	6	8*s.* to 10*s.* per cwt.	Buttons, gelatine, prussiates, and snuff-boxes.
Shoes	5	5*s.* to 10*s.* per cwt.	Shots and old iron.

sum,—from 20*s.* to 60*s.* on an average; but recollect that every application to art or science of this dead horse renders him of greater value; and it is for us, engaged in various ways in the arts of life, to see whether we cannot apply things that have hitherto been wasted. Five hundred horses die every week in London. The hair, you see, is worth from 8*d.* to 1*s.* per lb., and it is used for making hair-cloth, for stuffing mattresses, and making plumes, and bags for crushing seed in oil-mills. Then the hide, weighing 30 lbs., is

worth 8*s.*, which is perhaps not a great deal of money; but when you have from 300 to 500 a week dying within a radius of five miles from Charing Cross, it comes to some money. Then the skin is used for a variety of purposes; tendons you know may be made into gelatine, and glue, and jellies. I told you that you must not be particular about these jellies: when the poor old horse has drawn your carriage, served you in omnibus and cab, and died at last; even then you have not done with him, for his tendons may then serve you for your delicious jellies. Then again it is not an uncommon thing for man to eat horse-flesh. We do not eat it here knowingly, but they eat it on the continent of Europe. There is a story of a Frenchman, who thought we sold meat for almost nothing, for we sold it on skewers for a penny a skewer-full. Then there is the blood, which is carried to the prussiate of potash manufacturers. Then there are the internal tubes, which are used for the coverings of sausages; and, as I said of the jellies, we need not ask any questions about these coverings as long as they are sweet. The heart and tongue are evidently great "mysteries," for no one knows what is done with them. There is almost as much mystery about them as about the manufacture of the cloth of your coat. The heart, however, can be chopped up and mixed with sausage-meat, and the tongues may be sold for ox-tongues. On a recent occasion, when I stated this fact, a newspaper which reported my lecture added that it was all a mistake, and that the tongues were never sold for so inferior an article as ox-tongue: they were always sold as reindeer tongues. Now, passing over the fat, which is worth 3*s.* 4*d.*, I need not tell you that

horses' bones are as good as any other bones, and can be employed for the various purposes to which other bones are applied. The bones of a horse weigh about 160 lbs. and are worth 4*s.* 6*d.* per cwt. Then there are the hoofs, 6 lbs. of these, at 8*s.* to 10*s.* per cwt., which can be used for making buttons, prussiates, and snuff-boxes. I do not think that it is correct to say they are used in making glue. I think horses' hoofs are composed of the same material as hair. They are sold, it is true, to the glue-maker, but he sells them to the prussiate manufacturer. Even the poor old shoes are worth from 5*s.* to 10*s.* per cwt.; and even with regard to all these substances employed, there is nothing which cannot be used again and again.

Another source of valuable refuse is that from our fisheries:—

"Attention has frequently been directed to the substances wasted in the fisheries and returned to the sea as garbage, and to the detriment of the fisheries. The difficulty has hitherto been the collection and bringing together the refuse to one or more conveniently-situate manufactories.

"A Mr. Pettit recently patented a process for converting refuse and unedible fish into a pulpy homogeneous mass by sulphuric acid, desiccating it and mixing it with peat charcoal or some other drying material.

"Messrs. Molon and Thuneysen, the proprietors of similar works at Concarneau, on the west coast of France, and at Newfoundland, have established a fish-manure factory at Lowestoft.

"The fish are first decomposed by steam in a revolving cylindrical boiler, and the mass is then subjected to hydraulic pressure in coarse hempen mats or bags, so as to express the moisture. The hard cake of pressed fish, thrown out of the bags and broken up, is placed or slides and subjected to heat in a stove which will contain about half

a ton. It requires some hours to dry. When taken out, it is crushed or pulverized between millstones, and put into bags, holding about half a hundredweight, for sale.

"Two kinds of oil are obtained from the hydraulic pressure to which the fish is subjected, obtained by heating the expressed liquid, which facilitates the separation of the oil from the water. One quality is very pure, and sells readily; the other consists of the dregs, with a portion of the best oil. This might, by a proper apparatus, be purified, so as to render the whole available except the solid matter; and even this would be useful to soap-makers.

"A fish-manure factory is now in operation in the vicinity of Narragansett Bay, Massachusetts.

"The available offal from the Newfoundland fisheries is very large. About one million quintals of codfish are annually exported from Newfoundland. About one-half the fish—head, bones, and entrails—is thrown away as waste in the process of curing. Calculating roughly, out of every 1,000 quintals of dry cod (equal to 3,000 quintals of sound fish) there would be saved 650 tons of useful manure from cod refuse alone. Added to this there are about 600,000 seals caught every year. The bodies of these seals, which constitute their chief bulk, must give at least 50,000 tons of animal matter. In addition to these raw materials, the seas and bays around Newfoundland abound with fish of every kind, particularly the capelin, the dogfish, and others, which are peculiarly rich in oil, and can be taken in great quantities by the slightest exertion.

"In Galway very excellent azotized manures are made from the refuse of fish, bones, blood, and other substances chemically amalgamated, which contain from 32 to 50 per cent. of fixed ammoniacal salts and azotized matter.

"In the department of Finisterre, in France, a manure is made from fish. The fish undergoes a kind of cooking by steam, after which it is dried and pulverized. It requires about 500 pounds of fish to produce one cwt. of the powder, which forms an admirable manure.

"Professor Wilson, writing on the agriculture of the French Exhibition, thus speaks of fish manure:—'The fish, either the refuse of the market or otherwise, is cut into pieces and submitted to the action of high-pressure steam (four or five atmospheres) for about an

hour in suitable vessels. It is by that time sufficiently cooked, and is then ready for the presses, which expel a great proportion of the water, and leave the residue in the form of a cake. This cake is, by means of a coarse rasp or grating-machine, broken up into a sort of pulp, which is spread out in thin layers on canvass, and dried by means of warm currents of air. It is sold either in this state, or more minutely divided by means of the ordinary grinding processes. It is stated in this condition to correspond to 22 per cent. of the crude weight of the fish, and to contain from 10 to 12 per cent. of nitrogen, and from 16 to 22 per cent. of phosphate. The price was 20 francs per 100 kilogrammes (about £8 per ton), and the demand regularly increasing.'

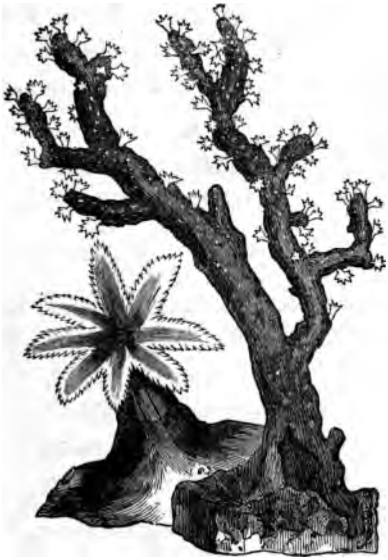
"The value of shell-sand for agricultural purposes has long been recognized; in Cornwall it produces a marked increase in the crops of roots and corn.

"Crushed or ground shells are much used as a dry covering for paths and walks in gardens, &c.

"Burnt shells, when formed into concrete, make a most substantial and imperishable wall. Calcined shells were formerly esteemed by physicians as absorbents."

With this Lecture I finish this part of my course. I have endeavoured to bring before you very hastily some of the chemical principles in operation in the arts and manufactures. I have also endeavoured to point out to you the natural history of these things, and have done so for the purpose of impressing upon your minds the importance of studying the structure and habits of the animals used by man. I think it is the duty of a civilized community to study the history and properties of those things to which they are so much indebted for their comfort and advancement. It is just in proportion as a larger number of the population get interested in the study of the nature and properties of the objects Of the external world, that the arts and manufactures

will be advanced. Whatever may be the occupation of a man, he will be much more likely to be successful in it if he has an intelligent apprehension of the nature of the materials which he uses from day to day. If this were better understood, there would be a much greater demand for a special knowledge of the nature and properties of the substances used in our arts and manufactures than has hitherto been evinced. You know that the Government of this country is making, in connection with this institution, an effort to diffuse science-education throughout the country. But this effort will be vain unless it is supported by the public. There must be an intelligent conviction on the part of the great mass of the community that such an education is essential to our advancement and progress in civilization. Our civilization is a thing essentially different from that of the Greeks and Romans, and we ought to be able to teach our children something more than was taught by these people to their children, great as they were in their day and generation.



ON SPONGES AND CORALS.

In the preceding Lectures I brought before you, more particularly, the parts of Vertebrate Animals which are used by man in the arts and manufactures. In this lecture I propose to take you back again to the Invertebrate forms of animals, and to dwell on those which are employed in any branch of human industry. Although my primary object here is not to teach you natural history, it may be as well, in this place, just

to present you with a natural-history classification of animals, in order that you may see to what groups of animals those belong which are familiar to you in the uses to which they are applied. Animals are divided by the naturalist into five great classes, the names of which, and some of the animals which are used by man, you will see in the following diagram.

I.

VERTEBRATE ANIMALS.

MAMMALS.—Monkey, Ox, Horse, Seal, Elephant, Pig, Deer, Whale.
BIRDS.—Ostrich, Swan, Eagle, Humming-bird, Pheasant, Peacock.
REPTILES.—Crocodile, Tortoise, Boa Constrictor, Frog.
FISHES.—Sturgeon, Bleak, Shark, Roach, Cod, Mackerel.

II.

ANNULOSE ANIMALS.

ARACHNIDANS.—Spiders, Mites, Scorpions.
CRUSTACEANS.—Crabs, Lobsters, Crayfish.
INSECTS.—Silkworm, Bee, Ant, Coccus, Gad-fly.
WORMS.—Earth-worm, Lug-worm, Sand-worm.
ECHINODERMS.—Star Fishes, Sea Eggs.

III.

MOLLUSCOUS ANIMALS.

CEPHALOPODS.—Cuttle-fish, Nautilus.
PTEROPODS.—Clio.
GASTEROPODS.—Snails, Whelks, Cowries.
BIVALVES.—Oysters, Pearl Oysters, Mussels, Tridacnas.

IV.

CŒLENTERATE ANIMALS.

JELLY FISHES.—Portuguese-man-of-war.
CORALS.—Sea Anemones, Red Coral, White Coral.
ZOOPHYTES.—Sea Fans, Polyps.

V.

FIRST ANIMALS.

RHIZOPODS.—Foraminifera.
SPONGES.—The Common Sponge.
INFUSORIA.—Monads.

I have omitted some of the smaller groups of animals, which, although recognized by naturalists, yield no forms which are either used by man or commonly recognized.

Now, in the preceding lectures the only animal belonging to the last four classes which I have dwelt uponhas been the silk-worm. As, however, there are many animals highly useful to man belonging to these other classes, I now propose to take up those which belong to the lowest class, and exhaust each class till we get to the vertebrate animals again. I shall, therefore, begin with the class of first animals—*Protozoa,* as they are called, from the fact of their low organization and the absence of those organs which distinguish the higher animals. It is in this group that we find those low organisms which have made it puzzling to naturalists to know whether they belong to the animal or the vegetable kingdoms. Thus, Ehrenberg placed with the infusorial animalcules, a group of organisms, known by the name of *Diatomaceœ,* which are now generally allowed to belong to the vegetable kingdom. These creatures are very minute and can only be seen by the aid of the microscope. (Fig. 2.) They move freely about in water of their own accord, but they have no recognizable stomach or mouth. When examined chemically, they are found to consist almost entirely of silex

or flint. From this cause, after they have once been formed, they are almost indestructible. In this way they have left an indelible record of their existence on the surface of the earth, and have impressed their history on the solid rocks of the globe. Their forms are very remarkable: they are square, or oval, or boat-shaped, or twisted. Many of them are perfectly spherical, whilst one family is triangular. Some have their silicious bodies supported on a stalk, whilst others send out long hair-like projections.

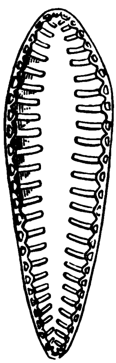


Fig. 2.

The Diatomaceæ occur in prodigious quantities in some parts of the world. In some instances it has been found that the principal part of solid rocks is composed of these minute creatures. Ehrenberg relates that in Sweden there is a rock called Bergmehl which is entirely composed of diatoms and other animalcules, and that they retain enough organic matter to become a source of food in times of scarcity. The rock known by the name of Tripoli is almost entirely composed of these minute creatures, whilst a polishing stone employed in Germany, and known by the name of polischiefer, consists of little else

The beautiful cross lines or markings presented by these minute organisms, under the microscope, have rendered them useful as a means of testing the powers of the microscope. It has been calculated that the little elevations produced by the cross striæ in various species of diatoms will give the following numbers for each square inch of surface:—

Navicula angulata	...	...	...	70,000
„ Fasciola	...	...	...	90,000
„ sigmoidea	...	...	...	105,000
„ Arcus	...	...	...	130,000*

Another group of animal-like plants are the Desmids. (Fig. 3.) But I must not detain you longer among these minute creatures. It is interesting, however, to be able to point out that amongst these smallest of living organisms some are directly useful to man. With regard to the indirect utility of the Infusorial Animalcules there can be no doubt. They swarm where waters are charged with organic matter about to decompose, and they appear to be created to arrest that putrefactive change in organic matter in contact with water, which, if not stopped, would produce most disastrous effects on the higher animals. They also serve as food for creatures higher up in the scale of organization than themselves, and which could not exist but for the myriads of these animalcules which teem in every drop of water.

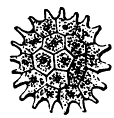


Fig. 3.

Belonging to a lower group of animals than the Infusoria are the Sponges. These creatures have such a plant-like appearance that up to the beginning of the present century they were regarded as plants. Dr. Grant, the learned Professor of Comparative Anatomy at University College, was one of the first to assert their animal nature. He watched the development of the ova of the sponge, and found that when freed from the parent mass they moved about like infusorial animalcules. This, perhaps, would not be regarded at the

* Sollitt and Harrison in *Quarterly Journal of Microscopical Science*, Vol. II., 1854, p. 62.

present day as sufficient proof of their animal nature, but, combined with the fact of the easily putrescible nature of the flesh of the sponge, and its resemblance to that of the animals, it is very significant.

The family of Sponges present a great variety of forms. They all consist of a hardened interior skeleton, which is covered over with fleshy matter. This fleshy matter is of the same nature as that of which many animalcules are composed, and if we suppose a number of unicellular animalcules condensed together so as to form a fleshy membranous substance covering the hard parts of the sponge, we should have a tolerable idea of its nature. The material from which the skeleton or hard part of the sponge is formed differs in various species. Sometimes it is composed of silex, sometimes of carbonate of lime, and more frequently of a horny matter. It is only the last kind of sponges that are useful to man. The silicious and calcareous sponges do not absorb, and are too fragile to be employed in the same way as the horny sponges. The silica in the interior of the silicious sponges is deposited in the form of delicate spicula, which are very beautiful objects under the microscope. There is a fresh-water sponge found in the Thames which contains these silicious spicules, and they are not uncommonly met with in the deposits at the bottom of our London cisterns. I may just say here, too, that this fresh-water sponge (*Spongilla fluviatilis*) has recently become a great nuisance in the supply-pipes of the water companies of many of our great cities. It entirely chokes the pipes in some districts of Dublin, and it has made its appearance in the supply-pipes of the Thames companies in London. When it dies, it

speedily decomposes, and gives out a most disgusting stench, rendering the water which flows over it exceedingly disagreeable.

The skeleton or hard part of the sponge is so arranged that its body is full of tubes, which open on the external orifice of the sponge. When the creature is living, and fixed in the water, currents of water pass into the smaller orifices, which, passing through the body of the sponge, are ejected from the larger orifices. (Fig. 4.) When taken out of the water, the fleshy part of the sponge speedily disappears, and nothing but its skeleton remains. When plunged in water, the irregular tubes of the sponge absorb the water, and retain it till it is squeezed out. It is this

Fig. 4.

property which renders the sponge so useful to man. It is, however, only the horny sponges that bear squeezing, or frequent immersion in water, both hot and cold.

Several kinds of sponge are brought into the markets and sold, but only two kinds are generally used. These are called Turkey and West-India sponges, and of these two the Turkey sponge is much the best. This arises from its tubes and orifices being smaller, and from its being more durable and less easily torn than the West-India sponge. This probably arises from its containing less calcareous matter.

The Turkey sponge is the *Spongia officinalis* of

naturalists, and is obtained from the Mediterranean Sea. Here it is found growing to the rocks or stones at the bottom of the sea in masses, from the size of an egg to that of a man's head.

The sponge is either obtained by dredging or diving, more commonly the latter. The inhabitants of the coasts of the Greek islands are described as very expert in this operation. The fishing season is between May and September. The diver goes out in a small boat, and from the perfect clearness of the water he can see the bottom; he carries a knife in his girdle, and on descrying a sponge he dives down and brings it up. He thus continues all day to dive after sponges, and frequently a hundred weight of sponge is his reward. It is, however, a very dangerous occupation, and the poor diver often sacrifices his life in his anxiety to increase his day's gains.

When the sponge is obtained it is removed from any loose stones on which it may be growing, and is then washed and squeezed to remove the flesh, and is afterwards hung up to dry. In this country we obtain our largest supplies of sponge from Greece, Turkey, and the Austrian territories. The annual importation into Great Britain is between 200,000 and 300,000 pounds. The value of Mediterranean sponge is from seven to sixteen shillings a pound, whilst other kinds of sponge do not fetch more than seven pence a pound. The high price of the Mediterranean sponge is a great inducement to adulteration. When it comes into this country it is often filled with sand. This sand has been introduced by the dealers, who moisten the sponge and press particles of sand into it in order to make it weigh more. The

sand thus introduced should be removed before the sponge is used. By beating and washing in water this may be secured. Sponge dealers are aware of this impurity, and often in purchasing sponge they make a bargain to be allowed to beat it a certain time before weighing. The number of minutes in which the sponge is to submit to this process, and the size of the stick, are often made points in the haggling.

The coarser descriptions of sponge are principally obtained from the coasts of the New World. Large quantities are annually obtained from about the Bahamas banks and the coast of Florida. From one thousand to fifteen hundred bales of sponge, weighing three hundred pounds a bale, are annually shipped from Nassau and New Providence. The value of the sponge exported from the Bahamas, in 1852, was £12,000. The peculiarity of this trade impresses itself upon the whole population. About the streets and outskirts of New Providence vast quantities of sponge may generally be seen covering fences, yards, and housetops, where it is left to dry. The Bahamas sponge attains a much larger size than the Turkey, and one piece is mentioned as being secured at Grand Bahama, measuring eight feet in circumference.

The uses of sponge are very numerous; not only is it employed for all kinds of washing and cleansing purposes, but it is of great use in making surgical instruments of various kinds. It is attached to waterproof cloth, and constitutes the material known by the name of *spongeo-piline*. This is employed for the purpose of applying hot or cold water or lotions to injured parts, and is a more cleanly, and often a more

efficient, application than a poultice. Sponge is also dipped into melted wax, and compressed between iron plates till cold; it is then cut up and used by the surgeon under the name of "sponge-tents," for the purpose of dilating wounds.

Sponge is often submitted to a process of bleaching, and is sold in the shops under the name of bleached or white sponge. It is made white by soaking it first in very dilute hydrochloric acid, which dissolves away all calcareous matter. It is then soaked and washed in cold water, and then exposed to water containing a very little chlorine in solution. Sometimes this white sponge is soaked in rose or orange-flower water, and a pleasant scent is thus given to it.

Another form in which sponge was formerly used is that of burnt sponge. The odds and ends of sponge and pieces of no value for anything else were collected together and exposed to heat in a covered iron crucible until the mass became quite black. This black powder was used in medicine, and employed especially as a remedy against goitre or bronchocele, or, as the disease is sometimes more commonly called, Derbyshire neck; it is not, however, now used, and it is interesting to know, that the remedy which has now taken its place in the treatment of disease—that is iodine—is actually found in burnt sponge. In fact, iodine is present in sea-water, and is found present in most of the lower plants and animals that inhabit the ocean.

Before leaving sponges and their uses I may mention that the skeletons of sponges are often found inside flints, and that it has been supposed that they are active agents in the production of the

flints of the chalk. Although not a general cause of the production of flint, the markings of sponges and their remains are often found in the interior of flints, thus indicating that they have formed a nidus around which the particles of silex or flint have been deposited. The way in which these flints have been formed has been an interesting theme of discussion. I have no doubt in my own mind, from an examination of the specimens collected by the late Professor Henslow and from my own observations, that the flint has been deposited, in all cases, by a process of precipitation from water as it slowly travelled through the chalk rock after it had been lifted from the bed of the ocean. The distinct layers which flints often present, especially during their decomposition, seem to support this hypothesis, as well as the difficulty of accounting for the occurrence of flints on any other hypothesis.

Before I leave these first animals, I must just refer to the Rhizopods. These creatures are of much interest to the physiologist, but of no great use to man; nevertheless there is a little family which, composed as they are of low organisms, inhabiting beautifully formed shells, cannot fail to excite a lively interest in all who have once seen them. This family of minute creatures are called Foraminifera (hole-bearers), because their shells are everywhere permeated with holes. (Fig. 5). They are very

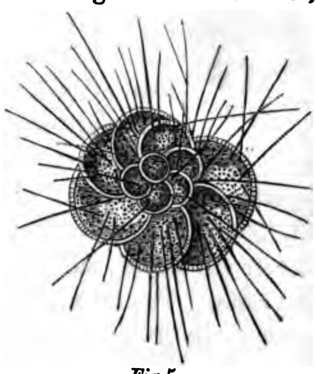


Fig 5.

abundant at the bottom of the sea of the present day. Numerous forms not seen before were obtained by the aid of the deep-sea soundings made for laying the cable of the Atlantic telegraph. They seemed to have been inhabitants of all seas, in all time, for they have left traces of their existence in the strata of the earth from the Silurian rocks to those of the most recent periods. They were especially abundant in the seas which deposited the chalk, and seem to have been the great agents by which that vast mass of carbonate of lime was deposited. If we take a quantity of chalk and brush it with a scrubbing-brush in a pail of water, and collect the coarser deposit as it falls and place it under a microscope, we shall get numerous forms of these Foraminifera (Figs. 6 and 7). It is thus that we come to the conclusion that these minute creatures have been the principal means of withdrawing from the ocean of the cretaceous period that carbonate of lime which we now find deposited in the form of chalk hills and downs.

Fig. 6.

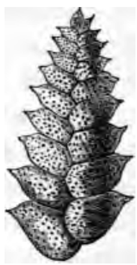


Fig. 7.

I must now, however, pass on to the class *Cœlenterata.* This new name, signifying creatures with a central stomach, agrees very much with the old group of Radiata, or rayed animals. It embraces the polyps, the jelly-fish, the sea-anemones, and the corals. The Cœlenterata are divided into two great groups, the Hydrozoa and the Actinozoa. The former includes the hydras and the jelly-fishes, which have no distinct stomach independent of the skin or outside

membrane, whilst the latter possess a distinct stomachal bag or cavity.

Of the Hydrozoa I have little to say as far as their uses to man are concerned. The little fresh-water hydra is the type of the group, and well repays a careful examination with the microscope. In the sea we find a group of these hydraform animals, which are called Sertularias and Campanularias; they inhabit a kind of skeleton which so closely resembles a plant, that when dried and picked up on the beach, they are constantly called sea-weeds (Fig. 8). You may, however, easily distinguish them from the algæ, or true sea-weeds, by a hand-glass, which will reveal the little cups in which the living hydras had their home. These zoophytes, as they are often called, are collected for the purpose of forming ornamental groups of marine objects, and are sold either by poor people who pick up a living by manufacturing these objects, or at the shops in most of our watering-places.

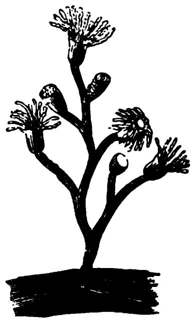


Fig. 8.

The jelly-fishes are another group of creatures most beautiful to behold (Fig. 9.), but affording no useful member that will serve me as a peg to hang a few remarks upon. One of their great attractions is their transparency, and this is produced by their consisting of little else besides water. Professor Owen says in his lectures that, having taken one that

Fig. 9.

weighed two pounds, he laid it out upon a board to dry in the sun, and when all the water was evaporated, it weighed only sixteen grains. Yet these things have been used as a manure. The late Professor Edward Forbes used to tell in his lectures a humorous story of his having met a farmer in one of his rambles who was carting these jelly-fishes on to his land, and on being asked how much solid matter he thought he had got in a cart-load, was greatly surprised at being told there was not more than he could carry in his waistcoat-pocket. Of course the farmer, like all "practical" men, went on carting the jelly-fishes on to his land, laughing at the follies of men of science.

The Actinozoa are a more highly-developed group than the last. (Figs. 10 and 11.) Just as the hydra may be

Fig. 10.

Fig. 11.

taken as the type of the last, the actinia, or sea-anemone, may be taken as a type of this group. The sea-anemones abound on our coasts, and there are few persons who have visited the sea-side that have not made their acquaintance. They are very simply organized creatures. They consist of an outside skin, or integument, and in the interior of this is a thin bag or stomach, which is fastened to the side of the skin by means of membraneous expansions. The stomach has a single

opening or mouth, which is surrounded by tentacles or feelers. In some species the creature has the power of retracting these tentacles within its mouth and shutting itself completely up, whilst in others the tentacles remain permanently extended. (Fig. 12.) These creatures are of no great service to man. They have, however, been eaten by man. Dicquemare, a French naturalist, tells us that the *Actinia crassicornis* (Fig. 10), and the *A. coriacea* (Fig. 11), are eaten in France. Mr. Gosse, in one of his amusing works, tells us that he tried the Actiniæ as food, and, although his account is anything but encouraging, there can be no doubt that they might serve as human food.

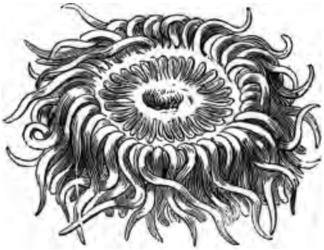


Fig. 12.

The great use of the Actiniæ at the present day seems to be to supply the demand made for marine creatures by those who indulge in keeping salt-water aquavivariums. For this purpose the various species of sea-anemone are very well adapted. They are exceedingly tenacious of life, and many of them present most beautiful colours. As a proof of their tenacity of life, I may mention that a friend of mine once brought some to London from the sea-side in a common quart wine-bottle. On arriving at home, he deposited his bottle with the anemones on the kitchen dresser, and proceeded to partake of his supper before making any arrangement for the further accommodation of his marine captives. After a supper of bread and cheese

and porter, he sought for the bottle with the anemones, but found, to his disgust and indignation, that the servant, regarding the contents of the bottle as nothing more than water, had emptied it and taken it to the public-house for the porter he had just consumed. Holding the bottle up to the gas-light, he saw the anemones still sticking to its side, and having a further supply of sea-water, he plunged them in, and to his great surprise they continued to live, and prospered even more than those that had not had the advantage of a bath of London porter. I may add here, that, with another object in view, I have experimented on these anemones, and have been surprised at the quantity of alcohol which may be added to the water in which they live without destroying them.

Such is the demand for sea-anemones for the purpose of being domesticated, that many thousands of specimens are weekly brought to London and sold by dealers in them for the purpose of stocking marine aqua-vivaria. As this is one of the uses of the humble creatures of which I have been speaking, I may perhaps be allowed to say a few words on these arrangements. They are an attempt to imitate on a small scale the ocean itself. The reason why animals are enabled to live in the sea is the same as that which enables them to live in the air. If there were no plants to take up the carbonic acid thrown out of the lungs of air-breathing animals, and to restore the oxygen which they destroy, they would soon perish. So it is in the sea. The sea-plants take up the carbonic acid thrown out from the gills of sea-animals and give out fresh supplies of oxygen gas. If we put sea-animals into sea-water

alone, they die for the want of oxygen gas and the presence of carbonic acid; but the plants restore the oxygen and clear away the carbonic acid, thus rendering life possible where before it could not exist. In all these arrangements great care should be taken to prevent over-crowding. This is alike the evil of our great cities and little artificial oceans. People want to get too much into a small space, and the consequence is that death and destruction spread around.

Many of the members of the Cœlenterate family may be introduced into the marine aqua-vivaria, especially those which form the substance called coral. Unfortunately few of these inhabit our own seas, so that they are not often to be met with. The aqua-vivaria may be also constructed for the exhibition of fresh-water animals, and amongst the Cœlenterata we have some in our ponds and ditches: as the green and brown hydra, and the creeping plumatella, which afford capital subjects for observation under the microscope. In fact, no one who possesses a microscope (and no household ought to be without one) should neglect to establish an aqua-vivarium, wherein to fish for specimens for examination. But I must not dwell on this subject; and I now come to speak of those forms of Cœlenterate animals which are familiarly known as coral animals. Some people call these creatures "insects"—coral insects—but this is a use of the word insect which cannot be tolerated at the present day. The naturalist confines the term insect to a creature with legs—six legs—and to this we must adhere. The coral animals are polyps, and if we suppose our sea-anemones reduced

in size, and several of them united together forming a common crust or skeleton, we should get a good idea of a coral animal.

The first of this group of animals to which I invite your attention, on account of its commercial importance, is the Red Coral. The beautiful red substance which we call by this name is the hard part or skeleton —technically the polypidom—of a compound animal, called by Linnæus *Isis nobilis*. The hard part which is used is covered over with a fleshy mass, and from this project the polyps which constitute the essential structure of the animal.

The red coral is found abundantly in the Mediterranean, in the Persian Gulf, in the Red Sea, and also off the island of Ceylon. In the Straits of Messina there is a coral ground of about six miles, from whence there is obtained about twelve quintals of coral annually. A quintal is about 250 lb. So that this district furnishes about 3,000 pounds of coral every year. The coral is also obtained in the bays around the islands of Corsica and Sardinia. The French have a coral fishery off the coast of Algiers, which is now a very profitable business. As long ago as 1833 there were from one hundred to one hundred and fifty boats employed in this fishery, and the annual value of the coral was estimated at £86,000. Coral has been brought lately in large quantities from the coasts of Hindostan, and it has been recently dredged in the southern province of Ceylon.

The method of taking the coral from the bottom of the sea is peculiar, but is the same in most localities. The season for coral-dredging in the Mediterranean is

from April to July. The dredging is carried on by means of boats. Each boat has a crew of six men, with a caster, who throws out the dredge and generally directs the proceedings. The dredge or apparatus employed is a kind of drag-net, and is composed of two beams tied across, with a weight to sink them. Nets are then attached to the beams in such a way that when they are sunk to the bottom of the sea they entangle the branches of the coral, which are then torn from the rocks by the rowers moving the boat with all their force. Several boats' crews are often obliged to join in order to carry the dredge through the forest of coral with which it gets entangled.

The older the coral is, of course within certain limits, the longer and thicker and more valuable it becomes. In consequence of a knowledge of this fact the coral fishermen avoid dredging in the same locality for several years after. They calculate that the coral takes at least twelve years to come to perfection, and avoid for this period of time dredging on the same coast bottom. When the coral is brought up, the fleshy matter and the polyps are cleaned off, and the branches then present a dirty-red appearance. It is not till it is cut into by the carver that the beautiful ruby colour it possesses is seen.

The skeletons, or hard parts, of corals contain but little animal matter, and the peculiar hardness and compactness of the red coral seems to arise from its containing a little more animal matter. Like the white corals, however, its principal constituent is carbonate of lime—a substance which, although we are familiar with

it as the friable common chalk, is nevertheless found in the condition of limestone and marble. The red coral has more the character of marble than of chalk, but is harder and more elastic than chalk. In addition to the carbonate of lime the coral contains magnesia and iron and a colouring matter. It was formerly supposed that the iron in the red coral was the cause of its colour, but this is now known to be erroneous. The same mistake was made when it was discovered that blood contained iron; but although iron assists in the development of the colour of the blood, it is the hæmatim of the blood which gives to it its colour; and so it is with the coral.

It is curious to find that red coral has been used as a medicine, and was selected in accordance with the doctrine of signs and seals as a means of restoring colour to the lips and cheeks. According to this doctrine, it was supposed that everything in nature bore upon it the sign of what it was good for, and as coral was red and bright and pleasing it was selected as a medicine for restoring the roses to the cheeks and joy to the heart. This was quite as sensible a doctrine as that of like cures like, and has this advantage, that persons were not confined to infinitesimal doses; the consequence was that red coral was often taken in doses sufficient for its iron to produce beneficial effects. It is still, I believe, used as a medicine by persons who have neither intelligence enough to comprehend the advantage of knowledge, nor faith enough to trust those who do. Let us not laugh at, but rather pity, those who, perhaps with all the means for enjoying the benefits

conferred by the increase of intelligence, yet, through ignorance and distrust, are doomed to wander in the outskirts of our civilization.

The uses to which the red coral is applied are very numerous. In the South Kensington Museum is a case, exhibited by the Messrs. Phillips, of Cockspur-street, who are extensive importers of coral, in which almost all the applications of this beautiful substance are seen. The larger branches are used for carving, and as the material is costly, and adapted to give definite outlines to the sculptor's work, great labour and ingenuity have been expended on objects of art wrought in this material. The Chinese, Hindoos, and Cingalese, all use this substance for the purposes of carving. It is, however, for ornaments for female adornment that red coral has been most largely consumed. In all ages it has been a favourite material for beads. The larger branches are turned into large beads, whilst the smallest tips are cut off, bored, and made into the well-known ornament called the *négligée*. It is a curious fact connected with these small irregular beads, that the minute holes made in them are done with the delicate fingers of little girls, as it is found the work is too delicate for being successfully performed by boys, men, or women. I would also remind you of a use of coral which has been made by many of you, but which, as you undoubtedly forget, I may recall, by referring to the coral and bells which so often, even at the present day, adorn the neck of babyhood. I think, perhaps, it is not so fashionable as it was, but I would suggest that a smooth, hard substance, that can be easily cleaned like

coral, is a source of great pleasure and satisfaction for a baby to bite at before its teeth have come through the gums.

I need not speak more in detail of bracelets, pins, brooches, coronets, armlets, and other ornaments made of coral. As long as the eye can be charmed with a beautiful colour, and delighted with elegant forms, coral will be worn.

Coral ornaments, however, differ greatly in price, and this depends upon the quality and colour of the coral. Some coral is soft and of a dull colour, and is altogether worthless, whilst other portions are hard and delicately tinted, and sell for five times their weight in gold. The coral which sells for the highest price is not that which has the deepest tint, but that which has the most delicate rose or flesh-like hue. At the present moment ornaments made of coral of the latter colour sell at enormous prices. In France the coral is commercially divided into five sorts: 1, the froth of blood (*l'écume de sang*); 2, the flower of blood (*la fleur de sang*); 3, the first blood; 4, the second blood; 5, the third blood.

Occasionally the red coral is found without any colouring matter at all. This white coral is used for making ornaments. The tips are bored in the same way as those of red coral, and they are then mixed together in the stringing of *négligées*.

The black coral of commerce is produced by a different species of polyp. In fact, it belongs to a group (*Antipathidæ*) of the Actinozoa, which are characterized by having their parts in five, or multiples of five,

instead of four. The species which is employed is the *Gorgonia antipathes.* (Fig. 13.) The hard carbonate of lime is deposited in little lumps, as it were, which are separated from each other by animal matter. It is not worked in any way, but, as the red coral is used, as an ornament in its natural state.

Fig. 13.

In the shops where corals are worked and sold, they sell a form of coral which is called "white coral." This is not the white variety of the red, but a true species of coral belonging to a very different family of the Cœlenterata. This white coral, *par excellence,* is a hard species of madrepore, and was formerly known to naturalists as the *Madrepora virginea.* It is now called *Oculina virginea.* It belongs in fact to that group of the Cœlenterate animals to which all our common white corals belong. This group is distinguished from the preceding by the fact that the hard parts of the coral are deposited in the interior of the animal. They are divided into groups according as their skeletons represent a perforated, tubular, tabulated, rugose, or smooth surface.

These corals, under the name of brain-stones, millepores, madrepores, harp-corals, and cup-corals, are well known for their use in ornamenting our chimney-pieces, drawing-room tables, and miniature oceans. They are all so very fragile that they cannot be worked. When living, these hard corals are covered with fleshy matter, from which project the polyps which give the

peculiar markings to their surface. The fleshy mass is easily removed, and when exposed to the air it frequently becomes beautifully white.

These corals are composed almost entirely of carbonate of lime. They occur in prodigious quantities in some of the seas of the world, and especially distinguish the South Pacific Ocean. So abundant are they in this ocean, that travellers, for many centuries after the discovery of the numerous islands it contains, attributed their formation to the coral animals. Although these creatures are most abundant in the Pacific, it does not appear that they have laid the foundations of its islands. We are indebted to Mr. Darwin for showing us, that, in fact, the South-Sea islands are but the mountain peaks of a continent fast sinking below the waters of the Atlantic; and that the corals are only temporary inhabitants upon those slopes which are now covered with water; for he has also shown that the coral-animals only live at a depth of about fifteen fathoms in the sea. Nevertheless, they exist over an enormous extent of the South Pacific, forming reefs, in one instance, upwards of 1,000 miles in extent. These reefs, composed entirely of the skeletons of these animals, are either found on the shores of islands or continents, or in mid-ocean. When skirting a shore they are called fringing reefs; but when occurring in the open sea they are called barrier reefs or atolls. The atoll differs from the reef in being of a circular form, and enclosing by its banks a lake or lagoon of sea-water. The study of these formations is full of interest, not only on account of their present

aspect, but on account of their relation to the past history of our globe.

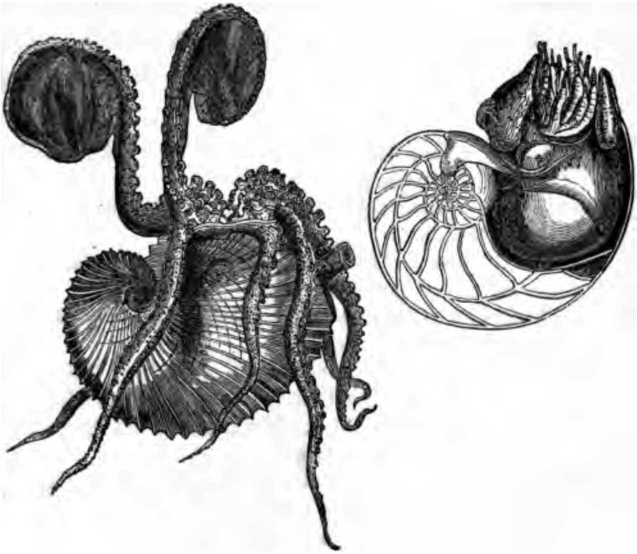
There is reason to believe that the great mountain-limestone range of hills in Yorkshire, Lancashire, and the north of England was deposited by the activity of these lower forms of animal life, and the stone quarries which furnish us with the marble for our chimney-pieces and other ornaments were originally deposited by the agency of these humble creatures.

The diversities of form which these corals assume give them alike an interest whilst living in the ocean, or when exhibited dead as ornaments in our museums and drawing-rooms. An American writer, who has studied these creatures, gives the following glowing description of their variety in the Pacific :—

"Trees of coral," he says, "are well known, and although not emulating in size the oaks of our forests—for they do not exceed six or eight feet in height—they are gracefully branched, and their whole surface blooms with coral polyps in place of leaves and flowers. Shrubbery, tufts of rushes, beds of pinks, and feathery mosses are most exactly imitated. Many species spread out in broad leaves or folia, and resemble some large-leaved plant first unfolding; when alive the surface of each leaf is covered with polyp-flowers. The cactus, the lichen clinging to the rock, and the fungus in all its varieties, have their numerous representatives. Besides these forms imitating vegetation, there are gracefully-modelled vases, some of which are three or four feet in diameter, made up of a net-work of branches and branchlets, and sprigs of flowers. There are also solid coral hemispheres, like domes, among the vases and shrubbery, occasionally ten or even twenty feet in diameter, whose symmetrical surface is gorgeously decked with polyp-stars of purple and emerald green."—Dana.

We cannot study these lower beings, and witness their direct and indirect uses to man, without feeling that the humblest creature has its uses in the universe,

and that all have a mysterious relationship to the position and wants of man. These lower animals are the first forms of that higher group of organized beings to which we shall find man himself belongs. In the study of their structure and organization, we come to understand the nature of those common tissues which in the higher animals are separated into muscles and nerves, and become the principal characteristics of animal life.



ON SHELL-FISH.

We pass in this lecture to a higher group of organized beings, and we shall find as we ascend, that just as animal structures become more complicated they are more useful to man. The group of animals, the uses of which to man I propose to consider in this lecture, are called *Mollusca,* and popularly known as shell-fish. Sometimes this latter term is also applied to crabs, lobsters, and shrimps, but those creatures have little or no relation with the Mollusca. When we therefore use

the word shell-fish, we shall apply it exclusively to Mollusca, although all this group of animals have not shells. Many of the lowest and some of the highest have no shells at all. The shell is, however, found in the most characteristic forms of the whole class. The naturalist divides the Mollusca into the following groups :—

POLYZOA. (Many Animals.)—Including the Sea Mats, and the genera Flustra, Alcyonella, &c.

TUNICATA. (Mantled.)—Including the tunicated or soft-shelled Mollusca.

BRACHIOPODA. (Arm-footed.)—Including Mollusca, with two valves, but having no hinges to their shells.

LAMELLIBRANCHIATA. (Flat-gilled.)—Including all the bivalved-shells having hinges.

GASTEROPODA. (Stomach-footed.)—Including Mollusks with one shell, or uni-valved, and many without shells.

PTEROPODA. (Wing-footed.)—Including a few Mollusks with motile organs like wings.

CEPHALOPODA. (Head-footed.)—Including all Mollusca furnished with tentacles and suckers attached to their heads, as the Nautilus, Argonaut, Cuttle-fish, and extinct Ammonites.

The creatures belonging to the first group of the Mollusca, now called Polyzoa, were formerly referred to the Polyps. They were associated with the polyps on account of the form of their skeletons, and the living animals which make them. The animals live in cells or cavities of the skeletons which they form, and have the power of protruding from them a circlet of tentacles, looking very much like the arms of polyps. On close examination of these tentacles, however, you will find that they are covered with cilia; hence Dr. Arthur Farre called them Ciliobrachiate polyps. Their internal structure is much more complicated than

that of any of the polyps. They have an alimentary canal with two orifices, a complicated muscular apparatus, and a distinct nervous system. It is on this account that they are now placed with the Mollusca.

They assume a variety of forms. Those who have spent a few days at the sea-side must have often picked up specimens of Flustra, which are called sea-mats. They are flat-lobed, plant-like-looking bodies, but when examined with a good magnifying glass they are found to be full of little cavities. The animals soon perish out of these little cells; but each cell was once the tenement of an individual polyzoon. These sea-mats are often collected and employed to add another form to the bouquets of sponges, polyps, and corallines which are often sold at the sea-side.

Another commoner form of these polyzoa is that called by John Ray the Sea Ragged Staff. On our eastern coasts, after a storm, this animal is often cast in great abundance. It is in the form of smooth-branched gelatinous masses, having something of the appearance of barley-sugar. The little molluscs which inhabit this fleshy recess shrink down into its interior as long as they are exposed to the air, but on being put into water, if not too much damaged, they may be coaxed into expanding their beautiful tentacles.

Fig. 2.

Some of the Polyzoa inhabit fresh water, and occasionally our London cisterns afford specimens, their eggs having been brought up in the water from the Thames. (*Figs.* 2 and 3.) The eggs of these fresh-

water forms are very beautiful objects under the microscope, and the whole group of animals, though of little

Fig. 3.

direct use to man, are of great interest in a zoological point of view.

The Tunicated Mollusks are the next most developed form of this group of animals. (Fig. 4.) They are shell-fishes with soft shells. Their shells envelop them as a tunic or mantle. They have two orifices, one for the ingress and the other for the egress of the sea-water which contains their food and aërates their blood. I do not know that they are of any direct use to man, but there is one point in which they are interesting to the physiologist, and that is, the composition of their tests or shells. These are composed of wood-substance, the same material as forms the trunks, the branches, and the ribs and cells of plants. It was a

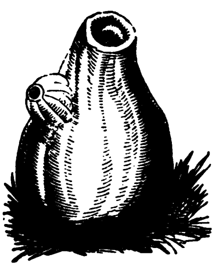


Fig. 4.

startling fact when first discovered, that animals formed wood as well as plants. Yet such must be the source of the vegetable fabric with which these tunicated mollusks keep the water from their shoulders.

It is, however, amongst the higher forms of the mollusca that we find those shells which are so interesting and so useful to man. The test of the tunicate is here replaced by hard shells, which are either single, and then called univalve, or double, and then called bivalve. We have two groups with bivalve shells, the *Brachiopoda* and *Lamelibranchiata;* and three with univalve shells, the *Gasteropoda,* the *Pteropoda,* and the *Cephalopoda.* As all these creatures form their shells in the same way, and as this is the principal part of these creatures used by man, I will speak of it first.

These shells are to the creatures they contain what his bones are to man. They support and protect the soft parts. Like the bones in the higher animals, they are composed of two substances, the one animal, the other earthy. The animal part resembles gelatine; the earthy part is principally carbonate of lime. They contain, however, small quantities of phosphate of lime, a little potash, and soda and acid. In one hundred parts of oyster shells there will be found—

Water	17
Animal Matter	2
Carbonate of Lime	75
Phosphate of Lime	3
Other Salts	3
	100

This will give an approximation to the composition of the shells of the mollusca generally, and will throw

some light on the question of their probable use as a manure. There is no doubt that in some soils calcareous matter acts very favourably, and then shells may be of service on account of the large quantity of chalk (carbonate of lime) they contain. But the animal matter and the phosphate of lime are in very small quantities, and at best the shells of the mollusca can act but as feeble manures. At the same time it should be recollected that where the animal remains in the shell, these creatures may become a very powerful manure. It is thus that even some of the lower forms of marine animals, as the starfish, and others, have been found very good manure, when thrown on the land entire.

But now let us look at the way in which the animal uses these materials to construct its beautiful residence. If we look at any of these shells we shall find they consist of two layers, one external and rough, the other internal and smooth. These layers run one into the other, and were at one time supposed to be a mere secretion from the body of the animal. We find, however, when we place a portion of shell under the microscope, that it gives indications of a highly-complicated and organized character. If we take the shell of the Pinna, for instance, and break a piece of the external coating of the shell off, and place it under a low power of the microscope, and examine it by a reflected light, we shall find that it consists of a series of six-sided prisms, which all fit in together, forming a most compact and fine piece of workmanship. A transverse section of the shell, which may be seen by transmitted light, presents a series of hexagonal cells, very similar to the

cellular tissue in plants. (Fig. 5.) In such preparations the hexagonal spaces are mostly transparent, but now and then a perfectly black space appears. Dr. Carpenter, to whom science is greatly indebted for the investigation of the structure of shells, says that this is due to the carbonate of lime which is deposited in a crystalline condition in the transparent cells, but in an amorphous form in the dark cells.

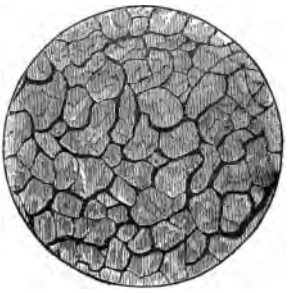


Fig. 5.

All bivalve shells partake more or less of this cellular character in their upper membrane. There are many shells, however, in which this upper layer is only very imperfectly developed. Such are the oyster and most univalve shells. The under membrane, or the nacre, as it is called, presents a very different appearance. When submitted to examination under the microscope, no cellular structure of any kind can be seen. It is, in fact, composed of a series of very delicate layers which are deposited one on the top of the other with the matter supplied by a membrane covering the animal called the "mantle." These layers are not of equal size and extent, so that they lie one over the other in a kind of imbricated manner,

Fig. 6.

their edges presenting a series of lines with waved edges. (Fig. 6.) It is this arrangement which gives to this substance the power of reflecting those beautiful iridescent colours which make them so well adapted for the ornamentation of papier maché work. For this purpose the *Ear-shells* (Haliotis) are more especially employed, as their flat surfaces adapt them for being cut up for the purposes of the manufacturer. The mother-of-pearl shells are also employed for this purpose. The brilliancy of the colours reflected from this iridescent surface depends on the thinness of the laminæ of the nacre. Where the laminæ are thick, there a dull white appearance is all that is seen. As an instance of this, I may mention the oyster, where scarcely any iridescence is seen.

In order to develop this beautiful character in a large number of univalve shells all that is necessary to be done is to remove the outer layer of shell-membrane. When shell-fish die in the ocean the waves toss the shells about and rub off this external layer, and we get thrown on our beaches quantities of shells, bright and iridescent, with the play of colours on their surface. Many shells which are used for ornamenting our sideboards and fire-places are prepared by removing this external layer with a knife, and afterward polishing the shell.

The cause ot this iridescence depends upon the decomposition of the rays of light. You know that where a ray of white light passes through a glass prism that it is broken up into blue, yellow, and red coloured rays. Just as the light is broken up in the glass

prism it is broken up in passing through the delicate laminæ of the nacre of shells. But in these laminæ one set of the coloured rays interferes with another set, and the consequence is that an infinite variety of colours is produced. The same phenomenon is observed in all delicate films lying one on the other. Who has not observed all the colours of the rainbow in a drop of tar falling on water, whether in a pail, a pond, or a river? It is the same with irregular glass surfaces. It can be produced by layers of varnish upon paper, and has been thus produced for ornamental purposes by Mr. Warren De la Rue. The colours on a beetle's wing, the glowing colours of a humming-bird's plumage, and a thousand beautiful mixings of colour in nature are produced by the same causes.

The exact nature of the changes which go on in the layers of the shell has been the subject of much difference of opinion. Whilst the older physiologists regarded the shell as the mere separation of so much earthy matter as a secretion from the body of the animal, the more recent school of microscopical observers regarded such structures as those presented by Pinna and other shells as a true form of cell development. This latter view has, however, been attacked with great ingenuity and success by Mr. Rainey,* who endeavours to show that the formation of structures, like those seen in the mollusca and even in bones, does not depend on cell-development but on the crystallisation of the carbonate and phosphate of lime in contact with organic matter. Mr. Rainey shows how various salts, when crystallising in solutions of gum, gelatine, and other organic

* "On the Mode of Formation of Shells, &c." London: Churchill.

materials, assume a spheroidal form, and he is inclined to give a very general action to this force, and the process which results he calls "molecular coalescence." I mention these facts not so much for the purposes of instruction as to show you how abundantly there lie around us in our every-day life materials for observation, the result of which may modify the most general theories of the nature and functions of living bodies.

But now let me draw your attention to one of the most interesting facts in the history of shell-fishes. Those beautiful ornaments, which we know by the name of pearls, are the produce of various species of shell-fish. Pearls vary much in size, and are found sometimes not bigger than a small shot, at others as large as a pea or a bean. They are found in the interior of certain species of shell-fish, and are the result of the deposition of the nacreous matter of the mantle around some central nucleus whereby they assume a globular or oval form. If a pearl is cut through it will present generally a grain of sand or some small portion of matter, around which successive layers of nacre have been deposited. The layers or laminæ are not, however, perfectly regular, but like the layers of nacre in the shell, the edges of one layer lie over the surface of another. It is from this cause that the same kind of interference of light takes place in the pearl as in the nacre, and the same kind of beautiful iridescence is observed. If an impression be taken of a pearl on a piece of wax or soft metal, the same kind of iridescence results in the moulded substance, and advantage has been taken of a knowledge of this fact to produce the same kind of lines artificially on metallic

surfaces for the purpose of producing the same play of colours. Buttons made of steel, and fine-lined in this way, have been manufactured by a machine.

Although pearls are evidently formed between the mantle and the nacre of the shell, they are not always found in that position, and are not unfrequently present in the interior of the flesh of the animal. This may be accounted for by the fact that the pearl is loose in the shell, and by increasing in size it at last presses its way into the soft parts of the animal. The cause of the production of the pearl is worthy the accidental introduction of a small particle of foreign matter, around which the nacre of the mouth begins speedily to be deposited. In some cases, however, it appears that the cause of the production of the pearl is the interference of a neighbouring fish. A large number of the one-shelled mollusks are furnished with a kind of awl-shaped proboscis, with which they are in the habit of boring through the shells of their bivalved neighbours, and sucking up their vital juices for their own sustenance. This unhappy practice is apparently resisted by the injured parties by a copious secretion of nacre, which solidifying serves as a protection against subsequent injury, and results in the formation of a pearl.

Although we might expect that pearls would be produced by all kinds of bivalve shell-fish, it is only a few species that have ever been known to yield pearls commercially. The pearls of "great price," which are the largest and most beautiful, are those obtained off the island of Ceylon, at Cape Comorin, and in the Persian Gulf. The species of mollusk which yields the pearls in these districts are known to naturalists by the name

of *Avicula margaritifera*. It is commonly known by the name of the pearl oyster. These oysters are found in great abundance off the island of Ceylon. Here there is a great pearl-fishery, which is under the control of the local authorities of the island. At certain seasons of the year the fishery is opened, and the shells are brought up by means of divers. The shells when landed are opened, and the pearls picked out of them. The shells are also useful on account of their nacre, which is called "mother of pearl." Pearls are valued according to the purity of their colour and size. There is one existing at the present time, which was obtained at the fishery of Catipa, in Arabia, and which was sold for £10,000. It is of a pear shape, and is above two inches in length and half an inch in diameter. The small dark pearls are of comparatively little value.

It may be news to some persons to be told that England was once celebrated for its pearls. Whether the report had any foundation in the value of the pearls procured in this island or not, there is no doubt that one of the visions of conquest that tempted Julius Cæsar to land with his soldiers on the shores of Albion was the reputation of its pearls. We are also told that after he had conquered England he presented as an offering to Venus Genetrix a buckler covered with pearls, which was hung up in her temple. Pliny, however, speaks disparagingly of British pearls. There is no doubt that from time immemorial one of the common bivalves of our fresh water rivers has been fished for the purpose of securing its pearls. The species is the *Unio margaritifera* of naturalists. (Fig. 7.) It is found at

the present day in many of our rivers, and on the Conway and the Tay the poor people still collect its shells

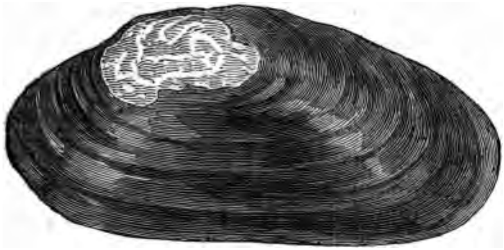


Fig. 77.

for the purpose of procuring its pearls. These pearls are small and dark, and are what are called "seed-pearls," and fetch only a very low price in the market. They are used for placing at the back or other concealed parts of pearl ornaments. I was told the other day by a gentleman that he had succeeded in obtaining at least one pearl in fifty of these shells which he broke on the banks of the Tay. The common edible mussel occasionally yields a pearl; and every fishmonger who sells opened oysters has a few of these precious objects to display as the result of his experience in opening oysters.

The mode of the formation of pearls seems to have been understood from a very early period, and allusions are frequently made in history to the practice of manufacturing pearls. Whatever doubt may be thrown on the authority of Olearius that the Indians of the Red Sea dived to the bottom of the ocean, and cutting open the oysters, obtained from them juice with which they made pearls artificially, there can be no doubt that from an early period the Chinese were in the habit of introducing between the mantle and the shell of the animal foreign substances which became covered with

the nacre, and thus coated with pearl. Such shells are frequently brought to this country, and several specimens are now to be seen in the South Kensington Museum, in which figures of various kinds, and other objects, have been covered by nacre. Whether these facts were known to the celebrated Linnæus does not appear; but in the latter part of his life he conceived the idea of manufacturing pearls in this way. This great man, in the year 1761, informed the King and Council of Sweden that he had discovered the art whereby the common fresh-water mussel might be made to produce pearls, and he offered to sell his secret to the government of his country for the benefit of the people. The secret was not purchased, nor did Linnæus divulge it; but it is not probable that he had discovered any other way of developing pearls than that ordinarily practised by the Chinese. It may be, however, still a question as to whether pearls might not be procured by the same artificial treatment of shell-fish which would repay the trouble attending it.

The composition of pearls is precisely the same as that of the nacre of the shell-fish. They are principally composed of carbonate of lime, with a small amount of animal matter. The carbonate of lime may be removed by pouring on them a strong acid, and the animal matter will alone be left. The easy solution of the carbonate of lime may have led to the practice of dissolving pearls and drinking them. Cleopatra, you know, won a bet of Antony, by dissolving pearls in vinegar, and swallowing them. They would be perfectly harmless; in fact, they seem sometimes to have been regarded by the Romans as a luxury, for Pliny tells us

that Clodius gave his guests pearls dissolved in vinegar to drink. In these cases the pearls were probably pounded, or the vinegar was first made strong, as our ordinary vinegar would hardly dissolve pearls unless broken.

The shells of the pearl oyster are of almost as much value as the pearls. The nacre of these shells is extensively employed in our manufactories for useful and ornamental purposes. For these uses not only is the shell of the pearl oyster employed, but the shells of other species, which possess a large nacreous surface. They are brought from various parts of the world. A large number called "silver lipped" are imported into Liverpool. Then there is another sort brought from Manilla, with a dark nacre, these are called "black lipped." Another and smaller kind still is brought from Panama. In manufacturing mother of pearl the external layer of the shell is removed, and the inner portion is cut into various forms for use. It has been lately much employed in the manufacture of buttons for ladies' cloaks and gentlemen's coats. For this purpose the dark shell is principally employed. It is a curious fact, that formerly, only the light shells were employed for this purpose, and the dark shells were regarded as mere refuse. Hundreds of tons of these shells have been thrown upon the roads and waste places of Birmingham, in former times; but such is the demand for them at the present time that the streets of Birmingham have been actually dug up for the purpose of procuring them, and large prices have been paid for waste ground where they are known to exist.

The mother of pearl shell is extensively employed by

the papier-maché manufacturers. This manufacture is an interesting illustration of the use of what would otherwise be refuse material. Waste paper is taken and mixed with oil, and reduced to a pulp. It is then moulded into various forms, and dried in an oven, when it becomes as hard as wood. It is then exposed to the air, and a coat of refined black varnish is applied to the surface. Before the varnish is perfectly dry, pieces of mother of pearl which have been cut in the form of leaves, flowers, or other ornamental objects, are laid on the paper. This being done, they are again placed in an oven, when the varnish dries, and causes the mother of pearl to adhere. A coat of varnish is now applied to both the pearl and the papier maché, and when this coat is dry, it is carefully scraped off the pearl, and another coat of varnish is applied till the pearl has the appearance of being inlaid. The mother of pearl ornaments thus attached to the paper are coloured by an artist, so as to procure the natural effect of the objects on the paper. The inlaying of the pearl is effected by a different process. The design required is first pencilled out with shellac varnish. When this varnish is dry, a strong acid is applied to the pearl which corrodes away at the parts that are not stopped by the varnish. The mother of pearl having assumed its required form, is placed upon the surface on which it is to lie, and the whole is covered with repeated coats of varnish, until it is brought to a perfect level. The nacre of many of the shells, especially the beautiful Ear-shell (*Haliotis splendens*), is used for the same purpose as the mother of pearl shells, and constitute a very elegant means of

ornamentation, especially in the case of the articles made of papier-maché.

The whole interior of the surface of the mother of pearl shells are often carved. Curious specimens of this kind of carving are brought from China. Travellers also know that at the monastery of Bethlehem in Judæa, the monks are in the habit of carving these mother of pearl shells, and they are purchased and diffused all over Europe. Specimens of these shells are to be seen in the animal product collection at the South Kensington Museum.

Another important use to which shells are put is the production of cameos. The term cameo is applied to any small carving on a solid surface, and shell cameos are extensively employed for brooches, pins, bracelets, and other ornaments. The most valuable shell cameos are cut upon the legs of a species of *Cassis* (*C. rufa*), a large shell found in the Mediterranean and known by the name of the Bull's Mouth. The nacre in these shells is found to be variously coloured in layers, and by this means an object may be carved in relief in white, resting upon a coloured basis. The art of cameo carving is a very simple and elegant one, and I have often wondered that it has not been taken up by ladies as a pleasing artistic employment. Any shell may be used for this purpose, and I have seen very pretty cameos produced upon very common shells. The practice of carving on shells is a very common one, and frequently shells with rude carvings on them are brought from the less civilized parts of the world. It is also a practice by which sailors wile away their

time at sea, and cowries with such carvings and all sorts of poetry on them may be often purchased at the curiosity shops of our sea-port towns.

Hitherto my remarks have more particularly referred to the general uses of shells, and I would now speak more particularly of species which are useful to man. In doing so I shall not pursue the subject in any systematic detail, but merely dividing the Mollusca into their two principal distinctions of Lamellibranchiata and Gasteropoda, proceed to speak of the useful species in the first of these groups.

Amongst the bivalve shells there is one which is remarkable for the absence of epidermis on the outside, and for the transparency of the nacreous layer within. This shell is called the *Placuna Placenta.* It is smooth and flat, and can be split into layers. It is found in the Chinese sea, and also on the coasts of northern Australia, and is used by the natives of China for windows instead of glass.

Many of the bivalve shells have the power of attaching themselves to stones, rocks, and other objects. This is the case with the common edible mussel, which is occasionally found in immense numbers fastened down to the surface of the rock. The mode of attachment is found in the structure of an organ called the byssus. This byssus consists of several filaments which are secreted by a gland situated near the hinge of the valves of the creature. When recently formed they are adhesive and become attached to the rock, by which process shell-fish become safely moored in the midst of the dashing waves of the ocean. In

the case of the Pinna, the filaments of the byssus thus formed are sufficiently delicate to be used for the same purposes as silk. In the Great Exhibition of 1851, a variety of products manufactured from Pinna silk were exhibited in the Neapolitan department. A purse and other articles formed from this fibre are exhibited in the animal product collection of the Museum at South Kensington.

There is often found entangled in the filaments of the byssus of Pinna a little crab, the presence of which excited the attention of Aristotle, who supposed that there was some sort of good understanding between the mollusk and crustacean, and that they each served the other a good turn in the economy of life. Whether this be the case or not, the same little crab is frequently found in the byssus of the mollusca of our own shores.

Some of the bivalve shells attain an enormous size. There is a genus known by the name of Tridacua, some species of which afford shells which are used as ornaments on our fireplaces and sideboards. To this genus belongs the font shell—the *Tridacua gigas.* A pair of these shells, weighing at least 500lbs., are to be seen in the church of St. Sulpice in Paris, where they are used as *peintiers.* They are occasionally used as fonts in the village churches of England, hence the name of font shell. These shells are found in the South Pacific ocean, where their large size has attracted the attention of all travellers. Mr. Darwin says, if a man put his hand into the opened shells of one of these creatures, he would never be able to withdraw it as long as the animal lived. Captain Cook observed them,

and tells us he found the animal in them weighed sometimes as much as 20lbs., and that they were very good eating.

Amongst the most useful of the Gasteropodous Mollusca, we must first mention the Cowries or Cypræas. The latter name is derived from Cypris, a name of Venus. These shells, when they are young, have a thin and sharp outer lip, and a prominent spine; but as they grow older the mantle extends over the lips on each side, and at last meets on the back of the shell. The consequence is that the whole of the outer part of the shell becomes covered with nacre, and when the mantle is removed, they present all over their surface the smooth appearance of the nacre. They are frequently marked in a curious manner, and beautifully coloured. There are about 150 species distributed in all countries, most of which are valued as ornaments.

Cypræa annulus is employed by the natives of the Asiatic islands to adorn their dresses, to sink their fishing nets, and also as money. This is the species of which Mr. Layard found the remains in the ruins of Nimroud. There is a small species known by the name of the money cowry (*Cypræa moneta)*, which is dredged in the Pacific and Eastern seas, and which is employed by the tribes of Western Africa as a substitute for other kinds of money. Several hundred tons of these shells are annually imported into Liverpool for the purpose of carrying on trade with West Africa. In the Friendly group of South Sea Islands, the orange cowry is used as a symbol of authority, and is worn alone by the chief of the tribe.

Another group of the univalve shells have excited

interest on account of their use, and that is the whelk, which produced the Tyrian purple of the ancients. One of the earliest dyes used by the nations of antiquity was the purple juice which exuded from a little gland situated in the throat of this mollusk. Man had his attention undoubtedly drawn to this secretion by the observation of the beautiful purple colour that is frequently observed on the nacre, in the throat of the various species of *Purpura*. This name, meaning purple, has been given to them on this account. On our own shores is found very abundantly a small shell, about a third of the size of the common whelk, and called *Purpura Lapillus*, which has the power of secreting this dye, and whose throat is stained as I have mentioned. Such was the estimation in which this dye was held at one time that amongst more than one of the nations of antiquity it was death for any one but the sovereign or supreme judges to wear garments dyed with Tyrian purple. With the Romans the purple was indicative of sovereign power, and their Emperors were alone permitted to wear it.

The shells affording the best dye were found in the rocks off the coast of Tyre in Asia. They were also found at Meninge, on the shores of Africa, and on the coast of Laconia, in Europe. The colour of the dye varied according to the district from which it was brought. That from Pontus, in Galatia, had a black colour, whilst the warmer the region the more violet the dye. At Rhodes the colour of the dye was a rich rose red. In the manufacture of the dye animals from different districts were mixed together so as to obtain the best effect. Pliny tells us that two hun-

dred of one sort were mixed with one hundred and eleven of another to produce the finest purple. Different names were given to characterize the sorts of these shell-fish. This dye, which was extracted by breaking the shells of the purpura, was often mixed with other sustances, which brought out more brilliantly the natural colour. The discovery of the use of Kermes by the ancients led to a diminution of the demand for the Tyrian purple, and eventually the method of extracting the dye was lost. This has recently been rediscovered; but in the next lecture we shall find that other substances from the animal kingdom have entirely replaced the use of the purple of Tyre in the dyeing of cloth and linen.

The shank, or chank-shell (*Turbinella pyrum*) is a large shell found in the Indian Ocean. It is used in the East Indies for cutting into armlets and anklets, which are known by the name of "bangles," and worn by the women of Hindostan. They are often highly ornamented. More than 300,000 of these shells are annually shipped from Ceylon to the ports of Calcutta and Madras. "Chanks," or "kamcho rings," are cut out of the shells by means of rude circular saws into narrow slips, which, when joined very accurately, give the whole the appearance of being formed from the most circular parts of the shell. There is a small process or button at the basis of each shell, which is sawn off, and the bottom, after being ground to a shape resembling that of a flat turnip, is perforated for the purpose of being strung. When thus prepared, they receive the name of "krantahs," of which two rows, each containing from thirty to forty, are frequently

worn round the necks of the sepoys in the East-India Company's service as a part of their uniform—in fact, as a substitute for their stocks. These shells are also used for beating cotton and the fine cloths manufactured in the city of Dacca.

There is a small shell extensively employed at the present time for ornamental purposes, and known under the name of "Venetian shells." They are used for making studs, necklaces, bracelets, and pins, and really form a very beautiful ornament. This shell is a small univalve, not unlike a Trochus, and belongs, I believe, to the genus *Phasianella*. The nacre is very brilliant, assuming various tints of blue and purple. Species of this genus are found in the Mediterranean Sea, and it is from this fact that they may have found their way to Venice, and thus to England, with their ordinary name. Shells of this kind, and also probably belonging to the same genus, are brought from Australia, and in the South Kensington Museum are several strings of them, which are said to be used by the natives of Tasmania as ornaments. They are prepared by soaking the shells in vinegar, which removes the epidermis, and the nacreous layer is then brought out by polishing. Various tints are afterwards given to these shells, by boiling them with tea and other agents which react upon the colouring matter of the shell.

It has always appeared to me that shells might be used more extensively for purposes of ornament than they have hitherto been. No one can look over a collection of shells without being struck with the variety of form and colour they present, and these qualities, combined with the bright smoothness

of their nacreous layer, might certainly be more extensively employed in the arts. There is, as every one knows, a rude manufacture of shells into baskets, boxes, pincushions, snuff-boxes, even dolls' dresses, and flowers, carried on at many of our watering-places. The parts of plants and flowers thus manufactured have sometimes a claim to be regarded as elegant, but at present this department of art must be regarded as in a low state. It is not, however, for the want of materials wherewith to make things beautiful, for these are most abundant in every ocean of the world.

The Cephalopodous Mollusca are the most highly developed of this group of animals. Although amongst these animals we find the most complicated shells, we nevertheless find here the mollusk taking leave of its shell altogether, standing, in fact, on that vanishing point where nature takes leave of the invertebrate animals, and passes to those with a backbone and an internal skeleton. It is in this group that we find the Nautilus, the Argonaut, the Cuttlefish, and the extinct Ammonite. If we make a section of a nautilus (*Nautilus pompilius*) shell, we shall find it composed of a series of chambers (Fig. 1), and the same peculiarity distinguished the shells of the extinct Ammonites. The creature lived in these chambers, which it successively builds and makes larger, living in the outer one till it has formed another. It is from this outer chamber it puts forth its head, armed with the formidable tentacles covered with suckers, which have led to so many exaggerated stories of its size and power to injure man. The shell of the nautilus is prized as an ornament. Its nacre admits of a beautiful polish, and it is often carved and mounted, serving the purposes of a vase.

The Ammonite, though obtained in a fossil condition, is often used for ornamental as well as educational purposes. In whatever strata they lie they absorb materials from the water which passes through the rock in which they are embedded. Thus their chambers are often filled with beautiful crystals of carbonate of lime, fluate of lime, or silex, and when cut and polished they have a very beautiful appearance. Others have the earthy matter of their shells entirely removed and sulphide of iron deposited in their place. Under these circumstances they receive a polish which gives them a beautiful metallic appearance. The shells of the Belemnite and other fossil species are often converted into a mass of carbonate of lime, and are popularly known under the name of "Thunder picks." Such thunder picks I have seen scraped at school and used as a substitute for pounce.

Of all the creatures of this group the Paper Nautilus (*Argonauta Argo*) inhabits the lightest and most elegant shell. (Fig. 1.) It is not, however, a chambered shell. Century after century had this beautiful shell been cast on the shores of the Mediterranean, and yet never was there found in it an inhabitant to testify to its rightful owner. At last it was caught at sea, and the argonaut was recognized as a Cephalopodous Mollusk. But why did it not die in its shell? It was left for Madame Power, a French lady, to answer this question, and she discovered that the graceful paper-like shell was the residence of the maternal argonaut; that she built this charming boat for her protection whilst nursing her offspring, but when these were able to shift for themselves, she left her fragile bark with the rest of her family, *thus accounting* for its being tossed empty on

the shores of its native sea. In all collections of shells the Paper Nautilus wins for itself admiration by its graceful form, its delicate structure, and pure colour. It was often copied by the older artists in glass and porcelain, and its form frequently re-appears amongst modern designs for articles of use and ornament.

Some of these head-footed mollusks, as *Loligopsis* (Fig. 8), have no external shells, and the best known of

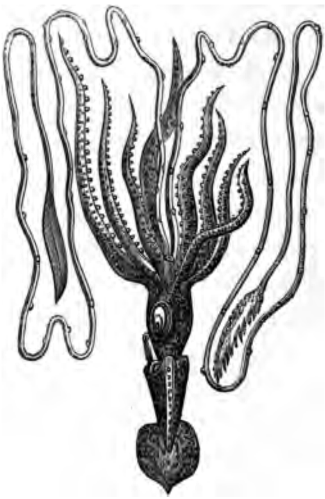


Fig. 8.

them in our own seas is the Cuttle-fish (*Sepia vulgaris*). Although this animal has no shell outside, it carries in the skin of its back a hard oval mass, called its "bone." This curious shell is composed of a hard layer outside, filled with layers of a softer substance, principally carbonate of lime, which has been used as a medicine. It is now, however, only used as pounce.

The cuttle-fish contains in its interior a pouch or bag which is filled with a dark-coloured fluid, hence this

organ is called its bag. This secretion is connected with the nutritive functions of the animal, but when it is alarmed or pursued the creature has the power of emptying this bag into the water, by means of which a cloud is produced all around it, and it is thus effectually protected from the pursuit of its enemies. It is calculated that one part of this substance in one thousand of water is capable of making the sea opaque. When this creature is caught on the coasts of the Mediterranean, where it is abundant, the ink-bag is extracted, and the liquid being poured out is allowed to dry as quickly as possible. It is then triturated with a little caustic, soda, or potash, and afterwards boiled with caustic lye for half an hour; at the end of this time it is filtered, and the caustic liquid is then treated with an acid till it is neutralized; after standing, a precipitate falls, which is collected, washed with water, and finally dried by a gentle heat. This substance is the dark pigment used by artists under the name of "sepia."

I am afraid there are many other occasional uses to which shells are put which I have omitted, but the remarks which I have made must serve to indicate the uses to which shell-fish and their organs are put in the arts and manufactures. I must, however, before I leave off, refer to the uses of these animals as articles of food. The shell is attractive and useful, but it is the soft body of the creature that dwells in it that is of most consequence to man. We have no record of the man who first ventured to swallow an oyster alive, but surely, if he could be found, he deserves a statue to his memory in Billingsgate market. It is, however, probable, that the inhabitants of sea-shores have tried

the taste of all the marine inhabitants of the ocean, and that the oyster is now universally preferred as the result of an extensive process of elimination. The soft body of this animal is principally composed of albumen, and consequently it is of easy digestion, and very nutritious. Our own coasts, even in the time of the Romans, were celebrated for the excellence of their oysters, and at the present day they are extensively cultivated as an article of diet. One hundred and fifty thousand bushels of oysters, it is calculated, are annually consumed in London alone. Above a million and a half are annually swallowed in Edinburgh, whilst upwards of fifty millions are yearly dredged by the boats in the French channel alone. The natural history of the oyster is one of great interest, and would amply repay the study to those who are engaged in its culture. The oyster is produced from eggs like other mollusks, but it is an error to suppose that they deposit their ova on one another's backs. Yet, under this impression they have been transported from one place to another under the supposition that the white matter frequently found on their shells is their "spat," or spawn. The eggs are really retained within the shell till they are hatched. How starts the young oyster then into the world? is a question which has been put, and so well answered by one who, above all others, was competent to decide the question, that I may be excused for quoting his answer in his own happy and inimitable language:—

"Not as unenlightened people believe in the shape of a minute bivalved, protected, grave, fixed, and steady oysterling. No; it enters upon its career all life and motion, flitting about in the sea as gaily and lightly as a butterfly or a swallow skims through the air. Its first appearance is as a microscopic oyster-cherub with wing-like

lobes flanking a mouth and shoulders unincumbered with inferior crural prolongations. It passes through a joyous and vivacious juvenility, skipping up and down as if in mockery of its heavy and unmovable parents. It voyages from oyster-bed to oyster-bed, and if in luck, so as to escape the watchful voracity of the thousand enemies that lie in wait or prowl about to prey upon youth and inexperience, at length, having sown its wild oats, settles down into a steady, solid, domestic oyster. It becomes the parent of fresh broods of oyster-cherubs. As such it would live and die, leaving its shell, thickened through old age, to serve as its monument throughout all time; a contribution towards the construction of a fresh geological epoch and a new layer of the earth's crust, were it not for the gluttony of man, who, rending this sober citizen of the sea from his native bed, carries him unresisting to busy cities and the hum of crowds. If a handsome, well-shaped, and well-flavoured oyster, he is introduced to the palaces of the rich and noble, like a wit or a philosopher or a poet, to give additional relish to their sumptuous feasts. If a sturdy, thick-backed, slimy-tasted individual, fate consigns him to the capacious tub of the street fishmonger, and from thence, dosed with coarse black pepper and pungent vinegar, embalmed partly after the fashion of an Egyptian king, he is transferred to the hungry stomach of a costermonger, or becomes the luxurious repast of a successful pickpocket."—"*Shell-fish, their Ways and Work;*" *by the late Professor E. Forbes.*

The dietetical qualities of the oyster might well detain us here, were this the place to discuss them. But I can only say that they are more digestible uncooked than cooked, that they are more palatable with lemon-juice than vinegar, and that both humanity and good taste dictate that they should be eaten as quickly as possible after they are opened. Of the edible shell-fish the oyster is undoubtedly the king. Nevertheless the scallop (*Pecten maximus*) is not to be disdained. Broiled and stuffed with forcemeat, and served in his own shells, he not only forms an ornament to the table, but a pleasing variety amongst the fish.

The Mussel (*Mytilus edulis*) is another of the mol-

lusca that furnishes a quota of food for the population of these islands. It is not often found on the tables of the rich, but they are to be seen in the London markets where the poor resort, and in the streets where people partake of such luxuries on foot. Professor Edward Forbes estimates that not less than 400,000 mussels are annually consumed in Edinburgh. They are not so digestible as the oyster, and are generally cooked before they are eaten. Large as is the number of mussels consumed as human food, it is nothing to the quantity in which they are consumed as bait. They are titbits which the whiting, haddock, and cod cannot resist.

Another bivalve sometimes eaten by the inhabitants of our coasts is the Razor-fish (*Solen maximus*). This creature would be interesting enough to us if it were not eaten, on account of its long, slightly-curved and truncated shells, which resemble the blade of a razor. It is not uncommon on our sandy shores, where it lives buried in the sand. It is not difficult to find, as above the spot into which it has retired it leaves an impression of two holes united, something like a keyhole. It is, however, almost useless to attempt to dig them up, they back away from you so skilfully. After many vain efforts to secure one of these creatures alive, I mentioned my failures to the late Professor Edward Forbes. "Oh," he said, with a waggish smile, "there is nothing easier: all you have to do is to put a little salt over their holes, and they will come out." I remembered, you know, the story of putting salt on birds' tails, and although I resolved secretly to try my friend's plan, it was so simple, I had not the courage to tell him that I would. I had, however, no sooner got to the seaside than I

quietly stole to the pantry and pocketed some salt, and then went alone at low tide to the sandy shore. As soon as I espied a hole I looked round, for I almost fancied I heard my friend chuckle over my shoulder; however, nobody was there, and down went a pinch of salt over the hole. What I now beheld almost staggered me. Was it the ghost of some razor-fish whose head I had chopped off in digging that now rose before me to arraign me for my malice, or was it a real live razor-fish that now raised its long shell at least half out of the sand? I grasped it, fully expecting it would vanish, but I found I had won my prize. It was a real solid specimen of the species *Solen maximus* that I had in my hand. I soon had a number of others, which were all carried home in triumph. Of course there were more than were required for science, and, at the suggestion of a Scotch friend, the animals not wanted were made into soup. When the soup was brought to table, our Scotch friend vowed it particularly fine, and ate a basin with at least twenty razor-fish in it. One table-spoonful satisfied the ladies, whilst myself and an English friend declared—against our consciences I do verily believe—that we had never eaten anything more excellent. I counted the number of the creatures I was able to swallow; it amounted to exactly three. After a tumbler of whisky and water, taken of course medicinally, arrangements were made for a dredge in the morning. The Scotchman was up at five, but I and my English friend could not make our appearance. Nightmare and other symptoms of indigestion had fairly upset us, and unfitted us for anything so ticklish as a dredging excursion. Now, I do not wish to say anything against razor-fish as an article of diet, but from what I have told you, they would seem

to possess an amount of resistance to the ordinary digestive activity of the stomach that would render it highly desirable to ensure, before taking them, such a digestion as a Highlander fresh from his mountain wilds is known to possess.

Then there is another favourite bivalve, and of which I can speak more favourably than the last two. This is the Cockle (*Cardium edule*). The cockle is very abundant on most parts of our coast, especially where there is sand, and upon the banks of estuaries. It is prized by rich and poor, and by some liked better than the oyster. It is equally good, raw or cooked. It may be boiled or roasted, eaten alone or as sauce to fish. It may be eaten in almost any numbers with impunity, and has not unfrequently staved off the pressure of starvation amongst the poor of our coasts. It attains a great size by culture. Some of the largest specimens I have ever seen I picked from the cockle-beds on the banks of the Ex, where an enormous number of this excellent mollusk are annually reared. It appears to me that the banks of our estuaries might be much more extensively used than they are at present for the rearing of these and other shell-fish.

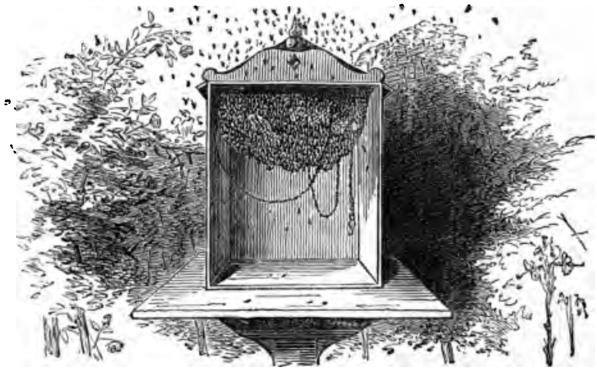
One of our neglected edible shell-fish is the Limpet (*Patella vulgaris*). It is very abundant on all our coasts wherever there are rocks, and it can be easily procured by the aid of a strong knife. It is a tough morsel, but nutritious withal. The people of Ireland think it a delicacy, and a considerable consumption of them as articles of diet occurs throughout the country. But, like mussels, they form excellent bait, and the late Dr. Johnston, of Berwick, calculated that *in Berwick* alone there were not less than 12,000,000 of

limpets annually used as a means of collecting other fish.

Then there are the Periwinkles (*Littorina littorea*), "pinpatches," as they call them on the coast of Suffolk. (Fig. 9.) They occur in myriads on the banks of some of our estuaries. They are regarded as a poor man's luxury, but I would recommend everybody to try them. Buy them alive, then boil them, and whilst hot pick the creatures out with a pin and eat them with vinegar and pepper. They are digestible and nutritious, and by no means to be despised. But they are so like snails—some one will say. And why may they not be very good in spite of that? You do not object to eat sucking-pigs because they are like babies, do you? Well, if you do, there is no help for you. But snails are very good. At the present moment there is a large consumption of snails going on in France as an article of food. The old Romans—and they were good judges of diet—ate snails; and our French friends, who are free from so many prejudices that we inherit, have exhibited an admirable philosophy in recurring to this neglected article of diet. The species of snail most employed is the large Roman snail (*Helix pomatia*), the *vigneronne* of the French, but many other species are eaten. They are cultivated by the modern French in special gardens, called *escargotières,* which resemble the old Roman *cochlearia.* In these gardens they are fed and fattened for the table. Pliny tells us the Romans cultivated snails whose shells held a quart of wine, but these could hardly have been the *vigneronne,* whose shell is of much more modest size.

Fig. 9.

Physiologically, then, there is no objection to the eating of snails, and our descendants, a hundred years hence, will perhaps wonder at the prejudice that deterred us from making use of an animal so manifestly intended for the consumption of omnivorous mammals like ourselves. If we turn to eastern nations we find a much larger variety of molluscous food entering into their dietaries. In addition to a large number of the bivalve and univalve forms, we find them eating the various species of *Cephalopods*. The nautilus and various kinds of cuttle-fish are eaten on the coasts of Siam, Japan, and China. Even at Brighton, I found, the other day, that people occasionally ventured on cuttle-fish. Now, all this proves that, after all, a large quantity of food runs to waste in the world for want of being looked after. However true may be the Malthusian theory, that the human race increases faster than its means of subsistence, it applies only to the recognized means of supply, and not to that vast store of unrecognized sources of food which can always be introduced where the human race is intelligent enough to inquire into the nature and sources of the materials out of which its fabric is manufactured, and by which its life is maintained.



ON INSECTS.

In a previous lecture I have shown you how great a service a single species of insect performs for man in the production of the article Silk. In the present lecture I wish to speak not only of insects, but of those other members of the annulose kingdom of animals which either supply useful products or establish such relations with man as to render it of importance that he should know something about them. It is, then, of the whole annulose group of animals that I propose to speak, of which the Insects form only a part, though that is a very considerable one. By looking at the following diagram you will see how the naturalist groups these creatures, and by the familiar

illustrations you will be able to form some idea of the groups into which they are divided :—

ANNULOSA.

RINGED ANIMALS.

A. ANNULOIDA.—Without joints.

1. Echinodermata.—Spine-skinned animals.
Examples: Star-fishes, Sea-urchins, Sea-cucumbers.

2. Entozoa.—Animals living within other animal bodies.
Examples: Tape-worms, Thread-worms.

3. Annelida.—Worms.
Examples: Leeches, Earth-worms, Sand-worms.

B. ARTICULATA.—With little joints.

1. Rotifera.—Wheel animalcules.
Examples: Animals with ciliated jaws.

2. Cirripedia.—Cirripeds.
Examples: Barnacles, Sea-acorns.

3. Crustacea.—Ten-legged aquatic family.
Examples: Crabs, Lobsters, Shrimps, Prawns.

4. Insecta.—Six-legged air-breathing articulate animals.
Examples: Wasp, Bee, Butterfly, Beetle, Flea.

5. Arachnida.—Eight-legged, air-breathing, articulate animals.
Examples: Mites, Spiders, Scorpions.

I shall begin with those of the simplest structure, which I have placed at the top of the list, and proceed to the higher forms which are placed below. It is not usual for naturalists to place the star-fishes amongst the *Annulosa*, but, nevertheless, as many of their kinds are evidently formed on the plan of the annulose animals, I have followed those naturalists who place them here.

The great type of the annulose group is a ring. If we suppose a series of rings, each with or without the power of producing four legs, we should have an arrange-

ment on the plan of which any of the forms of annulose animals might be produced. Thus we find the earthworm with a series of rings, and merely projecting stumps on each side of the body. From these we pass to the caterpillar stage of insect life, and from these to perfect insects, crabs, lobsters, and spiders, all exhibiting various modifications of the ring and its budding limbs.

In the *Echinodermata* we have a ring, but no legs. Amongst them we have the familiar forms of star-fishes, sea-eggs, and sea-cucumbers, but they are none of them of any direct value to man. They are sometimes thrown on our shores in prodigious quantities, and it would be a gain to know how they might be applied to some useful purpose. The other day I was passenger in a steamboat from Ipswich to London, and when off the coast of Essex, opposite Colchester, we passed through a fleet of small boats engaged in dredging. On inquiring what they caught, I was surprised to hear that it was the common star or cross fish (Fig. 2), which the

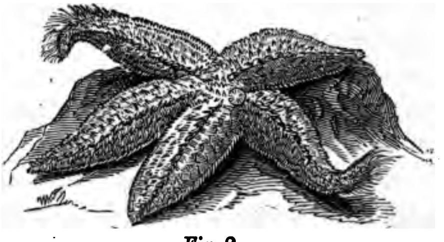


Fig. 2.

fishermen sold to the farmers on the neighbouring coasts as manure. These creatures contain both carbonate and phosphate of lime in their shells, and would make a much more profitable manure than their allies, the jelly-fishes.

Sea-eggs, especially tropical species, are sometimes preserved on account of their size and the beauty of their species. The spines of almost all the species, when cut into their sections, make objects of extraordinary beauty for microscopic examination. The sea-eggs, or urchins, would make equally good manure with the star-fish.

The group, however, of which we know least, and which, on account of their soft elongated form, are known by the name of sea-cucumbers, sea-slugs, and other names, are the most useful forms of this group. (Fig. 3.) A variety of species of *Holothuria* are eaten

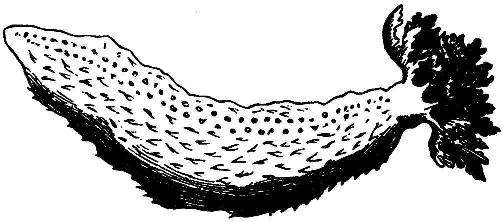


Fig. 3.

in China, Japan, and Siam. In the South Kensington Museum there is a considerable variety of these curious animals, which have been caught and dried, and which are exhibited for the purpose of drawing attention to the articles of diet of other nations. I have not tasted these things, nor do they look very tempting, but they are probably a wholesome and nutritious article of diet. I had a letter, the other day, from a gentleman living in the Shetland Islands, asking me if I could give him any information on the way in which these creatures could be cured, for he said "they are so numerous off the Shetland and Faroe Islands, that I am desirous of seeing if we could not send these creatures out to

China, as a set-off against the large quantity of tea which we in Shetland consume." Of course I cannot answer for the speculation; but this is one of the advantages of a general knowledge of the natural objects on the earth's surface, so that the people that live in one part of the world may freely interchange the products they have in abundance for those which they need with people who live in other parts of the world.

The next group of animals can hardly be said to be useful to man. They are, nevertheless, very troublesome, and a few words about them may be acceptable. It is a familiar fact, that all animals are liable to the attacks or, rather, the premeditated occupation of other animals. The older naturalists divided these invading animals, or parasites, into *Epizoa* and *Entozoa*—those which lived on the outside, and those which lived in the inside of other animals. The whole animal world is liable to these invaders.

> All fleas have little fleas upon their backs to bite 'em,
> And these again have lesser fleas, and so *ad infinitum*.

But it is not the enemy that boldly attacks us from without of which I wish to speak, but of those more insidious forms of the brute creation that take possession of our insides. There is only one family of these that I shall mention, and they are the Tape-worms. Every animal has its own tape-worm, and in every case the worm is introduced from without in the food. Like the butterfly, the tape-worm has a larval or caterpillar stage of existence, and it is in this condition it is carried into the stomach. This larval stage is always perfected in some form of food which the animal takes. Thus, taking the cat as an example, we find that the mouse

swallows the eggs of the cat's tape-worm, which, finding their way to the mouse's liver, form there young embryo tape-worms, which never come to perfection till swallowed by a cat. In the same way the eggs of the dog's tape-worm are swallowed by the sheep. These eggs find their way to the sheep's brain, where they give the poor animal the disease known by the name of the "staggers." The tape-worm, however, never comes to perfection in the brain of the sheep; in order to do this it must be swallowed by the dog. Now the animal that is destined to convey his tape-worm to man is the pig. What is called "measled pork" is the flesh of the animal attacked by the larvæ of the tape-worm. The young worm in this state has been called the *Cysticercus cellulosæ*, but no sooner is it swallowed alive by man than it assumes the form in his stomach of the well-known *Tænia solium*. (Fig. 4.) Well, now, the great practical fact we get at from this history is, to avoid "measled" pork, and especially if it be underdone.

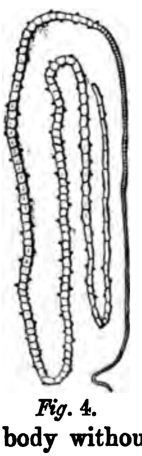


Fig. 4.

The next group of animals, the *Annelida*, brings us to one of very considerable value both medicinally and commercially. This is the Leech. There are several species, but the one which is useful to man is the *Hirudo medicinalis*. (Fig. 5.) This creature is easily known by its aquatic habits, frequenting fresh waters, and its elongated ringed body without any feet or legs. The most interesting part of its structure is its mouth, which opens by means of three slits, on one side of which is a series of v-shaped

teeth. Seventy or eighty of these little teeth have been counted in a single leech. It is by means of this arrangement that these animals are enabled to make wounds in their living prey. In addition to this, they have a series of muscles attached to the rings of their body, which, by expanding and contracting the stomach, enable them to draw up the blood or fluid from any objects they may have wounded. It is thus that they have become important aids to man in removing from any diseased spot of the body small quantities of blood. Leeches vary much in size, and of course will remove a quantity of blood in proportion to their size. This quantity varies from one to two drachms. The good, however, done by the leech is not so much in this way as by the oozing of blood from the wounds afterwards. This is greatly facilitated by fomenting the wounded part by the application of cloths soaked in hot water.

Fig. 5.

The medicinal leech is found in our own ditches, and the country people in some districts catch them and sell them to the neighbouring medical men. The great source, however, of leeches for this country is the Continent, and they are especially brought from France, Lisbon, and Germany. The importation of leeches appears to be on the decrease, for with the diminished tendency on the part of our doctors to bleed there is also a disinclination even to apply leeches. It is calculated, nevertheless, that from fifteen to sixteen millions of leeches are annually employed in this country, and that a capital of not less than £30,000 is employed in the traffic. A short time ago the supply of leeches fell so

short in France, that a decree was passed to prevent their exportation to other countries.

There are two ways in which these creatures are caught: the one is for the catcher to walk into the water with naked legs, and thus securing those which are unwary enough to attack him; another is to throw into the water where they live pieces of meat, which the leeches bite, and are then easily removed whilst sucking. Besides the common medicinal leech, there are other species of leech found in our ditches; there is one especially known by the name of the horse-leech (*Hirudo sanguineus*), and of which sad stories are told of the damage it does when substituted for the common leech. This, however, is quite a vulgar error, as it has been recently shown that these creatures have no power of penetrating the human skin at all. The common leech may be known by its back being of an olive-greenish or brown or blackish colour, whilst its abdomen is of a dirty yellow, or light olive green, and spotted with black. It has also six rings, which are of a rusty red or yellow colour, and spotted over with black. They sometimes have no spots on their abdomen, and such which are generally imported from Bordeaux, Lisbon, and Hamburg, are of inferior quality.

The common Earth-worm (*Lumbricus terrestris*), though not directly useful to man, yet performs so important an office that I ought not to omit to mention it here. This despised denizen of the soil, according to Mr. Darwin, is one of the principal agents in rendering the surface of the earth subservient to man's use in the garden and the farm. The worm, living in *the soil*, obtains the particles of food by which its body

is nourished by swallowing the particles of earth by which it is surrounded. It can only take up the finest particles, but when it has digested its nutriment out of them, it comes to the surface to deposit them in the form of the worm-casts, which so often disfigure our green lawns and garden-walks. These worm-casts, constantly accumulating, form at last the delicate mould which, from its absorbent action on the gases of the atmosphere, becomes the most nourishing soil in which a plant can be placed. Let us not then be too anxious to get rid of our worms, remembering that they do less injury to the roots of the plants amongst which they live than they do good by constantly bringing virgin soil to the surface of the earth.

On some parts of our coasts the sand-worms perform a work almost as important as their cousins on the main-land. Many of the worms found on our shores live in the sand, and some of them make cases out of the sand in which they live. Thus there is the little *Sabella alveolata*, which is constantly employed in making for itself a case, and as each tide of the sea brings up fresh sand it builds new portions of its case

Fig. 6.

till it constructs a tube several feet in length. As whole colonies of these little creatures work side by side, they build up permanent sand-banks, which in

many parts of our coast are a real protection to the shore, and prevent the sea from making inroads upon the land. Of these creatures the Serpula is very commonly seen in the marine aqua-vivarium. (Fig. 6.)

But I must now leave the annelides and the division of the *Annulosa* to which they belong, and speak of those tribes of animals which have more or less perfect limbs. Low down in this section are referred the Cirripedes, including the barnacles and sea-acorns. These creatures were placed by Linnæus amongst what he called the Multivalve Mollusca; but the history of their growth having been studied, they are now placed with the *Articulata*. The fact is, barnacles and sea-acorns begin life like young shrimps and crabs. They first lead a roving life in the ocean, till losing their eyes they run their heads against a rock or a floating log, and proceed to form a series of valves which they so construct as to enable them to put out their legs as organs of respiration.

Another group of animals belonging to this family, and just as interesting, and to which I am bound by the object of these lectures to make only a passing allusion, are the *Rotifera*—the Wheel Animalcules, minute things requiring a microscope to see them; they, nevertheless, belong to the animals of which we are now speaking, and possess a highly complicated organization.

The Insects must now, however, receive our attention; for, although I have already spoken of one of the members of this group that yields an important raw material of our manufactures, yet there are many other substances of importance to our comfort and civilization

that we owe to the agency of insects. I shall not here give you a classification of insects, but refer to the more important families which afford products useful to man. The "little busy bee," next to the silk-worm moth, is, perhaps, the most useful of insects. It belongs to the order *Hymenoptera* (membrane-winged), an order which is characterized by the majority of the species possessing stings. Large numbers of them also are distinguished for their social habits, of which the bees, the wasps, the hornets, and the ants are familiar examples. They frequently build for themselves houses in which they dwell. They use different materials for this purpose. The wasp and the hornet, with several other allied species, make a kind of *papier-maché* tenement, in which they deposit their eggs and hatch their young. The bee uses for this purpose the material we know by the name of wax. Although wax is a product of the vegetable kingdom, it does not appear that the bee procures this material ready made from plants, but she manufactures it herself from the sugar she collects as food for herself and the young.* However interesting it might be, space quite prevents my going into the history and economy of the honey-bee. You will find a great deal of very interesting information on this subject in a little book recently published by my friend Mr. James Samuelson,† of Liverpool. I would draw your attention, then, more particularly to the fact, that the usefulness of the Hive Bee (*Apis mellifica*) to man

* "Lectures on Food," p. 110.

† "Humble Creatures. The Honey Bee;" by James Samuelson. Van Voorst.

depends upon its constructing its comb of wax, the cells of which it fills with honey. The comb is entirely composed of the cells, which are of a beautiful hexagonal figure, and constructed with mathematical accuracy. The comb itself is made so as to depend perpendicularly from any object to which it is attached, and is composed of a double series of cells, which are placed back to back, or end to end, in such a manner that the end of each cell is closed by three wax plates, each of which assists in completing one of the cells on the other side of the comb. By this arrangement one of the great problems of the construction of all buildings is solved, that is, the greatest amount of strength with the least amount of material. Nevertheless, it does not appear that the cells are formed at once hexagonally, for Mr. Darwin and others have shown that the first cells are cylindrical, and that it is not till the insect wants material for further building operations, that it has recourse to the pulling down the cells already made. It is in this operation that it displays its skill, leaving only so much wax in its cells as is necessary to their strength and durability.

As the formation of the wax and the progressive construction of the comb is very curious, I may be excused for dwelling a little on the details. I have told you it is an erroneous notion to suppose that the bee collected wax from flowers. It is in fact produced by the bees as a secretion at that time of the year only when they build their combs. For this purpose the wax-workers suspend themselves in festoons from the top of the hive. (Fig. 1, p. 225.) Those which first reach the top

fix themselves by the claws of the fore legs to the roof, and are followed by others which attach themselves to them until an inverted cone or festoon of bees is formed, each end of which is attached to the roof of the hive. Before the commencement of the new comb, the interior of a hive presents a series of festoons of this description intersecting each other in all directions, the bees remaining in perfect repose. At this time the wax is secreted, and makes its appearance in little scales which exude between the segments on the under side of the abdomen, eight scales being visible in each bee. The wax being secreted, one of the bees commences the comb; having detached itself from the festoon, it makes its way from the roof of the hive, and after clearing a space by driving away the other bees, it detaches one of the scales from the abdomen by means of its hinder legs; this is then conveyed by the fore legs to the mouth, where it is masticated and permeated with a frothy liquid by the tongue, in which process it obtains a whiteness and opacity which it did not before possess. The particles of wax are then applied to the roof of the hive. Another scale undergoes the same process and is attached to the first. The bee thus continues labouring until all its scales are disposed of; it then quits its situation and is followed by another bee, which proceeds with its scales in the work already begun, depositing the wax in a straight line with the former deposition. The same operation is performed by many other bees until a considerable block is deposited. This block is generally about half an inch in length, the sixth of an inch in height, and the twenty-fourth of an inch in thickness,

and it is upon this that the formation of the cells commences.* The cells of the bee are used for two purposes—the nursing the larvæ, and, when these are perfected and gone, for storing up honey for consumption in the winter. Both the wax and the honey are useful to man.

The chemical nature of wax is very interesting. It has been the subject of numerous investigations, but its composition seems to have been thoroughly made out by the researches of Professor Brodie, of Oxford. According to this gentleman's researches, wax consists of three different substances which may be partially separated from each other by means of alcohol. There is myricine, which is insoluble in boiling alcohol. Then there is cerine, or cerotic acid, which is soluble in boiling alcohol, but crystallizes out of the alcohol when it becomes cool. Lastly, there is ceroline, which is soluble in hot alcohol, but does not crystallize on cooling. Of these two latter substances, beeswax contains from twenty to twenty-five per cent. Myricine constitutes the chief part of wax, and it is a substance having a similar nature to the fixed oils. You will recollect in the lecture on Soap that I showed you that the fixed oils are acids combined with a base. It is the same with this myricine. It contains a fatty acid called palmitic acid, the same as is found in palm-oil, and an oxide of a compound radical, melissyle; it is, therefore, a palmitate of melissyle. Myricine, and the other bodies which form wax, like the fats, are principally composed of carbon and hydrogen, hence it is

* Article, *Bee*, "English Cyclopædia, Nat. Hist. Div."

employed for combustible purposes in the same way as the fats and the fatty acids.*

The beeswax of commerce is obtained by melting the comb in water after the honey has been removed. It is then strained, remelted, and cast into cakes. It is of a pale yellow colour, and has a pleasant odour. It swims on water, and is brittle at the freezing point of water. It becomes soft and plastic at a temperature of 88° or 90° of Fahrenheit's thermometer, and fuses at a temperature of 154°. These physical properties render it of great use in the arts. It can be softened and moulded into any form, and when it is cold it does not adhere or stick to the forms with which it has been impressed. It is for this purpose extensively employed in all those departments of manufacture in which casts or moulds are employed.

Beeswax when brought into the market is of a yellow colour; this colour, however, gradually disappears by exposure to the air. It is not, however, uncommon for the dealer to melt the wax, strain it again, and colour it with annotto. White wax is formed by taking slices of the common wax and exposing it to the air, and when it is bleached, remelting it and forming it into cakes. It is from white wax that candles are made. These candles give out an excellent light, and are free from the greasiness and smell of tallow candles.† Wax is also used as an ingredient in ointments, and our word "cerate" is applied to an ointment made of wax (*cera*).

White wax is extensively used in the production of

* See "Lecture on Soap."

† See *ibid.*

ornamental objects, more especially models of fruit and flowers, and animal and vegetable substances. It is of especial value for museum purposes, in offering a material for the representation of vegetable and animal products, which could not be represented so conveniently in any other way. It has been employed for the purpose of representing various kinds of fruits and plants in the Food collection at the South Kensington Museum. I have also had modelled the various kinds of fish and flesh used as food, which could not be exhibited in any other manner. In the same way the anatomist finds it of great value in representing the normal and diseased structures of the human frame; and most of the anatomical museums in Europe are indebted to this substance for their most instructive specimens.

Wax affords also a beautiful material for constructing representations of plants, more particularly ornamental groups of flowers. In the Animal-product collection at South Kensington are some beautiful examples. In order to execute this kind of work the wax is melted and mixed with various colouring matters. The wax is then cut into thin leaves, which are employed by the artist.

There is another kind of animal wax which is brought from China, and is known by the name of insect wax. It is the produce of an insect belonging to the Coccus family, called *Coccus cerifera*. It is a secretion of the female insect, produced for the purpose of forming a cocoon for the protection of the young. I shall have to mention this curious family again presently.

Wax is imported into this country from all parts of the world. Large quantities are brought from Canada; Africa supplies considerable quantities; whilst about 300,000 pounds are annually shipped from Madras. Altogether we use in this country about 500 tons annually, which is worth about £200,000.

The wax of the comb is not, however, the only product of the bee employed by man. The cells of the comb, which have been vacated by the young bee, and those which have not been used by the young at all, are filled with honey. This honey is collected by the animal for feeding its young before they can fly, and supplying the whole hive with their winter food. It is collected by the working bees from the flowers of plants, and is deposited by them at first in the honey-bag or pouch. When they get home they disgorge the contents of this bag and deposit it in the form of the honey. The bee also uses the honey for the purpose of forming wax. Honey is composed of several substances. It contains both cane sugar (sucrose), and fruit sugar (glucose).* There is also a little yellow colouring matter in it, a little wax and gum, and, some writers say, lactic acid. If this latter substance is found, it probably arises from the decomposition of the glucose. Honey also contains traces of the volatile oils of the flowers from which the bees obtain it. Thus, particular kinds of honey contain special flavours from these volatile oils, and are celebrated accordingly. Thus, the honeys of Crete, Minorca, and Narbonne are flavoured with rosemary, the flowers of which plant the bees collect

* "Lectures on Food," p. 87.

their honey from; the honey from Hymettus, celebrated by the ancients, is flavoured by thyme; the honey of Provence owes its grateful flavour to the flowers of the lavender, whilst the delicious taste and perfume of the honey of Cuba is due to the oil of neroli, obtained by the bees from the orange-flowers of the district.

From the same cause the honey may be poisonous. Bees get their sugar from poisonous plants. Every schoolboy knows the history of the soldiers of Cyrus, who were poisoned with honey manufactured by bees that had fed on the flowers of the common *Rhododendron ponticum*. Other species of rhododendron, and the kalmias and azaleas, contain poisons in their flowers, which render honey collected from them dangerous.

Like sugar, honey ferments, and an alcoholic beverage can be obtained from the process. The mead, or metheglen of the ancient Britons, was fermented honey. It is sometimes made at the present day, but it has no pretension to vie with beers and wines as a beverage.

Honey is sometimes used in the arts as a medium for the preservation of animal and vegetable substances. In this way it acts in the same manner as sugar. It is said to have been used for this purpose by the ancient Spartans, who preserved the dead bodies of their kings in honey. As a food, honey acts on the system in the same way as sugar, and may be used under the same circumstances. It is more costly than sugar, but is extensively consumed on account of the pleasant perfume it possesses. More than 2,000,000 of pounds of honey are annually imported into the United

Kingdom, besides all that is obtained from our native bee-hives.

Bee-keeping is a very interesting occupation, and a great deal has been written on the subject. In London there is an Apiarian Society, of which Mr. W. B. Tegetmeir is secretary, and who have an establishment in the neighbourhood of the metropolis, where the most favourable methods of treating bees are pursued. The hives recognized by this society may be seen in the South Kensington Museum. A hive of bees at work was also kept for many years at this institution, showing that with a little care bees may be kept even in our large towns.

Before leaving the hymenopterous insects I must refer to the family of Ants. Some years ago, whilst editing the correspondence of John Ray, I was amused by the letters which passed between the great naturalist and Dr. Martin Lister, of York, on the subject of the "acid liquid of pismires." It had been observed, that when ants were bruised their juices afforded an acid secretion, which substance was afterwards known as formic acid. The attention of modern chemists being thus called to formic acid, Dumas discovered that it contained a base, a compound radical, which he called formyle. This base, with three atoms of oxygen, forms the formic acid. Now Dumas not only made this out, but he further discovered that the three atoms of oxygen might be replaced with three atoms of chlorine. He thus obtained terchloride of formyle. It so happened that, when ether had been employed as an anæsthetic, Dr. Simpson of Edinburgh was induced to look for some agent that might act even more beneficially than

ether in this respect. He tried the terchloride of formyle, and found it to succeed; and this is the agent which, under the name of chloroform, has been the means of alleviating a vast amount of human misery; and if occasionally it has destroyed life, it has saved so much that mankind owe a deep debt of gratitude to those who have successfully introduced it into practice.

This history is an interesting illustration of the importance of observing and recording. With what prodigious compression would some people in the world, who think themselves enlightened and educated, hold their sides, bursting with laughter, at the two old men squeezing dead ants, and dirtying their fingers with the juice. What childish waste of time! But wait a little, and Wisdom will be justified of her children. The "acid liquid of pismires" has become the great alleviator of human agony, and assuager of the sorrows of the primeval curse.

Another group of these hymenopterous insects is valuable to man on account of the effects of its natural habits. You all of you know what an Oak-apple is, and how that these apples appear on the oak about the 29th of May, when the children of loyal parents wear these apples, gilded, in their hats and button-holes, in commemoration of the escape of Charles II. from the soldiers of the Commonwealth. Although you may recollect this fact, it may be new to some of you to be told that these apples are not fruits—that they are not vegetable productions, but that they are the nests of an insect. If you watch the oak whilst it is budding you will find that a little insect deposits its egg in the interior of the bud. This it does by means of a pointed instrument

with which it is supplied, called an ovipositor. The egg having been placed in the bud, interferes with its normal growth, and the consequence is, that instead of a branch with leaves being produced, an oak-apple is the result. Again, many of you may recollect the pretty "robins' pin-cushions" that grow on the dog-roses during the summer time. These arise from the same cause. If you examine the pin-cushion, you will find that it consists of a mass of vegetable tissue which has grown irregularly around the egg of an insect. Another common plant attacked by one of these insects is the thistle. The stem of a thistle is often seen with a great wen or tumour on its surface, and when you examine it you will find it has been produced around the egg of one of these insects. Amongst the more remarkable of these excrescences are the Dead Sea apples. These are produced on a species of Solanaceous plant. They are remarkably like the fruit of a plant, but when opened they are found to contain nothing but the excreta of the young larvæ that were hatched in their interior. It was these apples of Sodom to which Milton alludes in the lines—

> Greedily they plucked
> The fruitage fair to sight, like that which grew
> Near that bitumous lake when Sodom flamed;
> This, more delusive, not the touch but taste
> Deceived, they fondly thinking to allay
> Their appetite with gust, instead of fruit
> Chewed bitter ashes.

Sometimes the larvæ feast in the interior of these excrescences till they are ready to enter on their more perfect existence; at other times they gnaw their way into the external world directly they are hatched. Now,

these excrescences, wherever they occur, are called galls, and the insects which produce them are called gall-flies; in this country they mostly belong to the genus *Cynips*.

When speaking of leather,* I told you that tannic acid might be easily converted into gallic acid—in fact, that it did become so by exposure to moisture and the air. Now, it would appear that this conversion of tannic acid into gallic acid takes place almost universally as the result of the attacks of these insects, so that we always find gallic acid in these galls. Hence, in fact, the name gallic acid.

It is on account of the presence of gallic acid that the galls are useful to man. This acid, when combined with the protoxide of iron, has the property of forming an intensely black salt, which is used in the production of black dyes for woollen cloth, calico, and other articles of dress. It is also employed in making that now almost indispensable article of our civilization, writing-ink. Gallic acid is separated from nut-galls, and is sold in its pure form in the druggists' shops. In this state it is used in medicine, and is one of the most efficient of our astringent medicines. It is also employed in the art of photography.

When used for dyeing and ink-making, the gallic acid is employed in the form of the galls or gall-nuts themselves. The galls most commonly used for these purposes are brought into this country from the Levant, and are the produce of a species of oak known by the name of *Quercus infectoria*. These galls are about the size of a marble, and are covered on the outside with a number of

* "Lecture on Leather," p. 64.

small tubercles or projections. They frequently have a little hole in them, which is an indication that the maggot has escaped. Those of a bluish colour, and without holes, are considered the best; while those which have holes lose their colour, become lighter, and are regarded as inferior. The common nut-galls vary much in the quantity of gallic acid they contain. Those called Aleppo galls are the most valuable. When used for making ink, the best galls should be employed. I give you here a receipt for making writing-ink. I have copied it from Cooley's "Cyclopædia of Practical Receipts." This ink you will find write well with a quill; if you use steel pens, you had better put in less gum:—

"Aleppo galls, well bruised, four ounces; clear soft-water, one quart; macerate in a clean corked-bottle for ten days or a fortnight, or even longer, with frequent agitation, then add of gum arabic (dissolved in a wine-glass full of water) one ounce and a quarter; loaf-sugar, half-an-ounce; mix well, and afterwards further add of sulphate of iron and green copperas, crushed small, one ounce and a half; agitate occasionally for two or three days, when the ink may be decanted for use, but is better if the whole is left together for two or three weeks."

Now, there are two things not mentioned in this receipt: first, that the ink is better when the galls are roasted before they are used; and next, that a few drops of some essential oil, dissolved in spirit, as lavender or cloves, should be added to prevent the ink becoming mouldy.

When gallic acid is heated to 410° Fahrenheit, pyro-gallic acid is formed; and when heated to 480°, meta-gallic acid is produced. Now, for some purposes for which gallic acid is used, pyro-gallic acid is preferable. This is the case in photo-

graphy. The photographer uses pyro-gallic acid in his developing solutions. When he has got his picture on the paper or plate, it needs to be brought out, darkened, and this is done by brushing over it a solution of aceto-nitrate of silver and pyro-gallic acid.

The trade in galls is very large. In 1850 upwards of 270 tons were imported into Liverpool. Many galls besides oak-galls are brought into the British markets. The peasants of Thrace and Macedonia collect from the branches of the terebinth-tree a gall having the shape of a horn, which is sold for dyeing the fine silks of Brusa. In Persia, Bokhara, and Cabul, the pistachio-tree yields a gall which is employed for dyeing. The tamarisk is attacked by a cynips, which is followed by a small gall, highly valued in the markets on account of the large quantity of gallic acid it contains. The common oak of this country has lately been attacked by a cynips, differing from the oak-apple cynips, which produces a gall-nut of the same size as the common gall-nut, but instead of having tubercles on the outside, it is perfectly smooth. This gall contains acid, but not so much as the foreign form. It, nevertheless, occurs in very large quantities and is on the increase, and perhaps it will one day be worth while to collect it for the sake of its gallic acid. A gall-nut is now brought in considerable quantities from China. It has a very singular shape, is larger than the common gall, and is hollow in the interior. It is very brittle, and of a brownish colour. This gall is not, however, the *produce* of a cynips. In the interior are found the

remains of aphides. It is not known from what plant it is produced.

The next order of insects which claim our attention on account of their value to man is the *Coleoptera*, to which the Beetles exclusively belong. There is no group of insects more interesting to the naturalist than this, on account of their number and the great variety of their forms. It is, however, only a small group that is directly useful to man, and those are the beetles which secrete in their bodies a principle which has the power of vesicating the human skin when applied. Many insects have stings, and others produce irritating secretions; but it is the group of "blistering flies" which are used by man. The type of this group is the common Spanish or blistering fly of the druggists' shops. This insect belongs to the genus *Cantharis*, and its specific name is *vesicatoria*, which it has got on account of its vesicating properties. (Fig. 7.) There are, however, several other genera and numerous species of beetles which possess this vesicating property, and Moquin Tandon thus distinguishes them :—

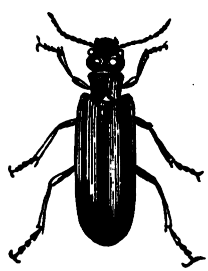


Fig. 7.

Wings...	Normally developed Antennæ	Filiform...............		1. Cantharis
		Claviform. Articu-lations	11.	2. Mylabris
			9.	3. Cerocoma
	None			4. Meloe.

I shall here confine my description to the one which is most used at the present day, and which, in fact, is the only one that is used for medical purposes—the *Cantharis vesicatoria*. This insect is distinguished by its bright

shining surface and uniform dark-green colour. Its filiform antennæ, without knobs, will enable you to separate it from the other genera with which it is associated in its blistering properties. The antennæ present an exception to the metallic green of the rest of the body, for they are black. When living the creature exhales a very strong, disagreeable odour, which it retains for a considerable time after death. The males are much smaller than the females.

The common blistering fly occurs occasionally in England, but it is extremely rare. It has been taken in the counties of Kent, Essex, and Suffolk. They are more common in France and Spain. Hence they are sometimes called French flies and Spanish flies. They are very abundant in the island of Sicily, from which they are sent in large quantities to other parts of Europe. Like all insects, however, they are uncertain in their appearance. In some years as many as twelve tons of cantharides have been shipped from Sicily. You may judge of the immense number of these insects thus destroyed, when I tell you that fifty of them will scarcely weigh a drachm.

This beetle is a vegetable feeder, and attacks a variety of trees, as the lilacs, the jasmines, the roses, the apple-trees, and the poplar; but its favourite tree is the ash. It sometimes attacks the ash in such numbers as to destroy the tree. They are taken early in the morning before the sun is risen by shaking the branches of trees, when they fall into cloths which are spread below. They are then immersed in boiling water or hot vinegar, and then allowed to dry upon a horsehair

cloth. A recent recommendation is to expose them to the vapour of chloroform, which perhaps would answer as well as anything for killing them. In fact, the killing of insects is always a very difficult thing, if the object be to preserve their bodies entire. My ingenious friend, Mr. Buckton, recommends the cyanide of potassium, which being put at the bottom of a closed box containing the insects, and moistened, will exhale the vapour of hydrocyanic acid, which speedily destroys life.

The cantharides are used in medicine both for external and internal use. They are not often given internally; nevertheless many physicians regard them as a valuable agent in certain forms of nervous disease. When given in large doses they are poisonous. There is a vulgar error with regard to their action on the system, and they are sometimes given secretly in poisonous doses. The best antidote that can be given under these circumstances is potash or soda.

As an external application the *Cantharis vesicatoria* is used for the production of blisters on the skin. The general way in which the beetle is applied is in the form of a plaster, made of the powdered flies and wax. This is spread on sticking-plaster, or on wash-leather with a margin of sticking-plaster, and applied to the part of the skin on which it is desired to produce a blister. In the course of from eight to twelve hours, the vesication is produced. If it be thought desirable to continue the irritation, then an ointment made of lard and the powdered flies is applied.

Vinegar and alcohol both extract the active principle

of this beetle, and a solution in vinegar or acetic acid is found to act more speedily as a vesicant than the ordinary blister.

The vesicating property was attributed by the ancients to the hairs upon the animal's body. Galen thought that it depended on a principle contained in the body, and held the curious notion that an antidote to its poisonous effects on the system was deposited in the wings. It was in 1810 that M. Robiquet, a distinguished French chemist, found out that the bodies of these insects contained an active principle, which he called cantharidine. It is white and crystalline, and emits an excessively acrid odour. Applied to the skin, it produces vesication, and when taken internally is a most active poison. It is very volatile, and easily dissipated at the temperature of the air. It is soluble in alcohol and acetic acid, but not in water. The cantharidine is found in all parts of the body, but in some parts more than another. The antennæ, legs, and horny parts contain less than the soft parts of the interior. Its quantity is something less than a half per cent, or about two grains in an ounce. The volatility of the cantharidine renders it very desirable that when kept the insects should be placed in well-stopped bottles, and in a cool place.

The other species of *Cantharis*, with those of *Mylabris Cerocoma*, and *Meloe*, which have blistering properties, contain the same active principle. Some of them contain even more of it than the common blistering fly. This is the case with the great Indian blistering fly, the *Mylabris Cichorii*, which feeds on chicory in the country about Dacca and Hyderabad.

From thirty to forty thousand pounds of blistering

flies are imported every year into this country. Suppose one fly to be sufficient for a blister, this would give as the result the fact that her Majesty's subjects endure upwards of a quarter of a million of blisters every year. This is a painful consideration; but when we reflect how much pain of a more dangerous character this blistering pain relieves, we can but feel indebted to the humble instrument which, in the hands of Providence, thus ministers to our relief.

The last group of insects which claim our attention are the *Coccidæ*, or Scale insects. Most persons are more or less acquainted with the little uninteresting insects that attack almost all our green-house plants, and which are generally most offensive and least observed when they stick to the leaves and fruits of plants in the form of oval or irregular-shaped scales. These scales generally represent the young insects in their pupa stage. The *Coccidæ* belong to the order of insects called *Hemiptera*, or half-winged, from the undeveloped state of their wings. The female, indeed, of all the families has no wings at all. She has, however, antennæ and legs. The male is larger than the female, and is distinguished by two long projecting hairs from the last segment of the body. The female crawls about on the surface of the particular plant to which it belongs, and when she deposits her eggs, she immolates herself by leaving her body as a kind of case for their protection.

These insects are very numerous, and upwards of thirty species have been named as natives of Great Britain. Some of them have been probably introduced with the plants which they attack. The mealy bug, as it is called, and which attacks vines, pine-apples, and

other plants in hot-houses, belong to this family of insects. It is of a reddish colour, and is covered with a white, mealy, powdery-looking substance, from which circumstance it has taken its name. Another of these insects is found on the leaves of the orange, and there is one which is very commonly found on the outside of the fruit of the orange. This last form of the family every one can have the opportunity of examining for himself by the purchase of an orange which is attacked by them. A very interesting and instructive account of this insect has been recently published by Mr. Richard Beck, of the firm of Messrs. Smith & Beck, opticians. Mr. Beck not only makes microscopes, but like his distinguished relative, Mr. Joseph Jackson Lister, the inventor of the compound achromatic microscope, knows how to use them.

The great majority of these insects are little better than pests, but I have introduced the family to your notice because of their useful members. It might puzzle any one at first to conjecture for what uses these little creatures are sent, and perhaps our lady friends will be surprised to hear that they are indebted for their red petticoats and scarlet stockings to this little group of insects. One of these coccidæ yields us carmine and another yields us lake; so that you see, humble as they are, they contribute largely to the showy colours with which some people delight so much to adorn their persons.

The coccus, which yields carmine, is known by the name of cochineal. It is a native of the New World, and attacks or lives upon the plant known by the name of the Nopal. This plant is a species of cactus, and was

called by Linnæus, on account of its harbouring the cochineal insect, *Cactus cochinillifera.* The native country of this insect is Mexico, where it was observed by the Spanish conquerors of that country, who found the inhabitants cultivated it for the sake of its red dye. The culture of the cochineal insect has extended from the New to the Old World, and it is produced in India, Java, and Algiers, and many parts of Europe. It is, however, from America, Mexico, and Honduras that the chief supplies of this article are still obtained.

The cochineal, as it is called, consists of the bodies of the female insect. (Fig. 8.) The male insect has wings. (Fig. 9.) These insects are found wild and collected, and the wild and cultivated sorts are distinguished in the Mexican markets by the names of *grana silvestre* and *grana fina*, the latter being considered the best. The insects, whether found in the woods or reared in gardens, are collected in the same way. They are brushed off the leaves into a basin and then plunged into hot water for the purpose of killing them; they are then put upon a sieve to dry, and assume the form of the little dry grains of cochineal. It is calculated that it takes 70,000 of these minute insects to make a pound. In 1855, before red garments became fashionable, we imported 1,400 tons of cochineal, which was valued at about £700,000, and would contain, you will find, about 220,000,000,000 of these insects. Since then their consumption has probably greatly increased.

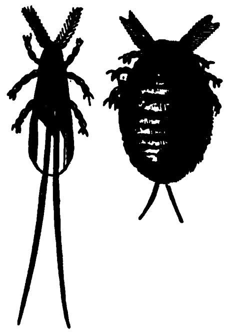


Fig. 9. *Fig.* 8.

The cochineal assumes different characters according to the way it is prepared. When dried in an oven instead of the open air, or dried upon cold plates, it assumes an ash-grey colour, and is then called silver cochineal or *Jaspeado*. When dried upon heated plates they are black in colour and are called *Negvo*. After the insects are dried they are sifted, and a dust is obtained consisting of the broken fragments of entire insects, which is collected and sold under the name of *granilla*.

The red-colouring matter, known by the name of carmine, as well as much that goes by the name of lake, is made from cochineal. There are many ways of making carmine. What is called English carmine is made by boiling cochineal with carbonate of potash, and then adding alum and a little isinglass. Sometimes cream of tartar, and at other times salts of sorrel are added, but the process of preparation generally involves the addition of potash and an organic acid. By precipitating a solution of cochineal with acetate of lead, and then removing the lead by sulphuretted hydrogen, Mr. De la Rue has obtained an acid which he calls carminic acid, and which appears to be the really active matter in the colouring of the cochineal. Carmine is one of the most powerful of colouring matters; one grain of it, it is said, will dye a single silk fibre upwards of three thousand yards in length.

Of course, cochineal has been used in medicine. There is scarcely anything so absurd, from an infinitesimal dose up to powdered mummy skin, that has not been employed as a remedy for one disease oı another. Cochineal with salt of tartar is a popular remedy

for whooping-cough, and of course the cough will get well if you wait long enough, and so it would with infinitesimal doses. I may add, then, that we have no knowledge of any higher value in cochineal in the treatment of disease than that it gives a brilliant colour to physic; and this, I suppose, is the reason it is admitted into the list of medicines of the London Pharmacopœia.

Before the introduction of cochineal into Europe, the production of another insect, belonging to the same family, was employed for colouring purposes in Europe. This substance was known by the name of "grains of kermes," and the tree from which it was gathered was supposed to bear it as its fruit. The history, however, of the product is the same as that of cochineal. The insect which produces it is a coccus, and the tree it attacks is the evergreen oak (*Quercus Ilex*), hence the name given to the insect is *Coccus Ilicis*. This oak is not unfrequently cultivated in Great Britain, but I am not aware of the insect attacking it in this country. It is common in France, and on the shores of the Mediterranean, from whence it is still brought in small quantities into the markets of Europe.

The appearance of the kermes is very different from that of the cochineal, and its grains or balls are more like small galls. The fact is, the insect in this case forms for itself a little cocoon in which its eggs are deposited, and it is the whole mass of the cocoon that constitutes the kermes. The grains of kermes produce the same colour as cochineal, and probably its colouring power depends on the same acid. No pains are taken to cultivate the kermes insect. It is found extensively in Algeria, and the red Fez caps, which find their

way into the European markets, are dyed with kermes. Carmine is also made from it. The value of the exports of kermes from Algiers to France is set down at about 18,000 francs, or £750. Altogether, the consumption of kermes in France is about 3,000 kilogrammes. There is another form which is very abundant in Poland, and is extensively exported from that country into Turkey, where it is employed in dyeing red. The insect which produces this form of the kermes is called *Coccus Polonicus*. It attacks a species of polygonum, the same genus of plants to which our buck-wheat belongs, and this species has got for itself the name *coccifera,* because of its favouring the attacks of this insect.

But there is yet another coccus, of more interest and value than any of which I have yet spoken. This is the lac insect: the *Coccus Lacca.* The habits and economy of this insect are much the same as those of the other Coccidæ. The female is a wingless creature, having even less perceptible organs of locomotion than those of the other species. She lives on various plants, but likes best to attach herself to the bark of the branches. In doing this she makes a little puncture in the bark, and there appears to exude from this puncture a quantity of vegetable matter which eventually surrounds the lac insect and her eggs and larvæ, and produces on the branch an irregular brown mass, which encircles it and which when broken has a resinous aspect. This is gum-lac. It is found on various trees in the East Indies, which is the country from which it is brought to Europe. These trees are some of them distinguished for yielding a milky juice. This is especially the case with the *Ficus Indica,* the Indian fig, and the *Ficus religiosa,*

the sacred fig, from which gum-lac is gathered in the greatest quantities. It is also found upon the jujube-tree (*Zizyphus Jujuba*), the *Butea frondosa*, and the *Croton lactiferum*.

The lac is known in the markets in various forms. There is first the stick lac, which is the exudation attached to the branch of the tree. When this is examined carefully it will be found to contain, in the midst of the resinous matter, the body of the female insect, hatched and unhatched eggs, and the dead larvæ of the insect. In the little holes produced by the body of the mother is found a minute drop of red fluid. It is this drop of colouring matter which, on being extracted, constitutes what is called lac-dye. This dye is brought into the market in the form of hard cakes, of a dark, dirty, purple colour. It is produced by reducing the stick-lac to a coarse powder in a hand-mill. It is then thrown into water and allowed to soak for sixteen hours. It is afterwards trampled on by men four or five hours, until the water has taken up the colour from the gum. The whole is then strained through a cloth, and a solution of alum in hot water is poured over it, and the decoction containing the colouring matter is drawn off. The colour is allowed to deposit, and is placed on a canvas strainer to drain. It is then made into cakes and dried, and the mark of the manufacturer is placed upon it.

The resin which is left after the dye is separated is brought into market as seed-lac and shell-lac. The seed-lac are the small pieces of the broken resin. The shell-lac consists of broad flat pieces, which are the resin which has been softened in hot water, and pressed

between leaves so as to make it assume the form of flattened cakes. It has various colours, brown, red, orange, and yellow. The thread-lac is prepared in England. It is melted and drawn into fine filaments, and is considered better for many purposes in threads.

Both the dye and the resin are important commercial products. Upwards of 1,500 tons of the two products are annually imported from the East Indies into England, and their estimated aggregate value is 80,000 pounds. The cakes of lac, before they are used, are either dissolved in sulphuric acid or in a strong solution of tin. It is employed in the dyeing of scarlet colours, and also in the preparation of carmine-coloured pigments. The colouring properties of lac dye seem to depend on an acid called laccic acid, and which comports itself very much like the carminic acid of cochineal. The scarlets formed from the lac are quite equal to those from cochineal; the pinks, however, are not so delicate.

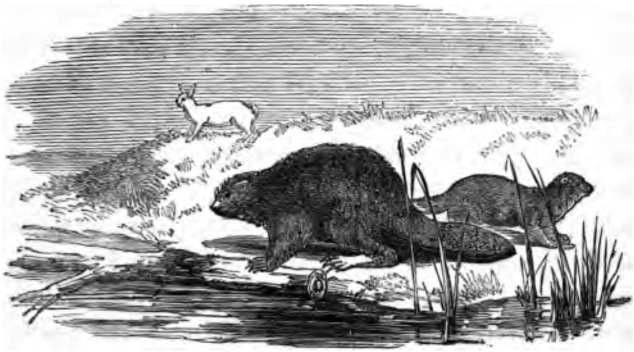
The gum lac, or resin, is a heavy compound substance. It contains margaric and oleic acids, also a neutral principle called laccine. It is used for many purposes in the arts. The greatest consumption is in the manufacture of sealing-wax. It has just that amount of melting power, tenacity, and elasticity that fits it, above all other substances, for keeping our secrets when written on paper. It is, however, for this purpose, mixed with other substances. The red sealing-wax has its colour given it by vermilion; white sealing-wax is made with bleached gum lac. Coarse sealing-wax has a good deal of resin in it. The best kind of sealing-wax contains about five parts of shell-lac, twelve of

Venetian turpentine, and one of Peruvian balsam, which are melted together, and mixed with the vermillion. Shell lac mixed with gum sandarac and Venetian turpentine, and dissolved in alcohol, form what is called lacquer, a kind of varnish used for heightening the colour of brass and bronzed articles. Lac is also used as a stiffening for the bodies of silk hats before the silk is put on. So that you see our little lac insect does not *lack* for interest and utility.

But I must leave the insect world, and hasten to conclude my remarks on annulose animals. The crustacea are distinguished from insects by their aquatic habits, although they are not all found in the water. There is a group known to the naturalist as the isopodous crustacea, to which belong many species, found in the dry ground. There is one genus known by the name of *Oniscus*, the species of which are commonly called woodlice, and which may be said to be useful to man as having formerly been used as a medicine. They were recommended to be swallowed whole, but as they have no active principles in their body, they could be of little service.

The most useful forms of crustacea are those which we eat. Nevertheless, crabs' eyes and crabs' claws formed part of the ancient Materia Medica. You must not, however, suppose that crabs' eyes meant the visual organs of those creatures; they were round concretions found in the stomachs of these animals, more especially during the season of moulting. Like the claws, they consist principally of carbonate of lime, mixed with some phosphate, and perhaps they were beneficial as a medicine on account of the latter ingredient.

That group of crustaceous animals to which the crab, the lobster, and the shrimp belong, are useful to man on account of the wholesome and agreeable food their flesh affords. These creatures are all covered with an external shell, which is very interesting on account of the proof it affords of a unity of plan amidst the most diverse organization. In the broad crab and long-tailed lobster, the ringed structure of these animals may alike be seen. Their well-articulated skeleton is moved with great force by means of the muscles that are attached to its interior, and it is these muscles which are the source of food to man. The flesh is composed principally of gelatine and albumen. The first of these substances renders them very well adapted for making into soups, whilst the albumen renders them less digestible than many other kinds of food after they are cooked. They contain little or no fat, so that they are generally eaten with sauce, or served up with salads containing oil. They appear to be more liable to decomposition than other kinds of animal food, and should on that account be always eaten fresh. However interesting it would be to give you an account of our edible crustacea, I must refrain, as I have already extended this lecture beyond due bounds. We must also take leave of the invertebrate class of animals. I shall proceed in the next lecture to speak of those vertebrate animals which afford us their skins for clothing and other uses, and after that we shall be retained by the vertebrate group of animals to the end of the course.



ON FURS.

In the present lecture I propose to bring before you a sketch of the natural history of animals yielding what we call Fur. I have previously spoken of the use of the skin, and shown you how valuable it is when converted into leather. In the manufacture of leather the hair is removed from the surface of the skin. But the hair itself is of value to man, and when left upon the skin it becomes one of the warmest articles of clothing that man can put upon his back. In the earliest record of our race we find that our first parents were clothed with the skins of animals. In fact, wherever man has found it necessary to protect himself from the influence of a low temperature he has had

recourse to the skins of animals, with no further preparation than was necessary for keeping them from decay. At first, all the preparation they underwent was exposing the skins to the air till they became sufficiently dry to be worn. Under these circumstances it was found disagreeable to wear the raw hide next the skin, so the hairy side was turned towards the body. When, however, the arts of life began to be developed the skins thus worn excited disgust, the skin was more carefully prepared, and the hairy side was exposed. It was, probably, the preparation of these skins which led to the art of tanning and the conversion of skins into leather. The wearing of skins was, however, confined to the nations of the north; and long after the processes of spinning and weaving had been employed by the natives of southern climates, northern nations clothed themselves principally with skins. This practice is frequently spoken of, both by Greek and Roman writers, as indicative of the barbarian tendencies of the northern nations. At the same time we find the early Romans occasionally wearing fur dresses on state occasions, and the poorer classes and rustics adopting this practice of their barbarian neighbours. As the populations of the north became better acquainted with Rome they exchanged their furs for garments of wool and silk, and gradually the use of fur dresses was introduced into the south of Europe. They are now extensively employed, even in eastern countries, but little mention is made of the use of fur dresses amongst the ancient Hebrews or Egyptians.

From being despised, and then occasionally worn, fur dresses, especially after the northern conquest, came

to be extravagantly estimated by the more civilized nations in Europe. At first the furs of indigenous animals were employed, then they were imported from all parts of the world. The more expensive the dress, whatever animal it was made from, the more it was esteemed. It is said that in every court in Europe they formed a part of the state costume of the reigning family. They not unfrequently formed the objects of special legislation. Only persons of a certain dignity were permitted to wear them, and in some countries the extravagance in the use of furs was so great that the clergy denounced them altogether. In England the wearing of furs is referred to in the sumptuary laws of Henry VIII. Thus no nobleman was allowed to make use of sable unless he held rank above that of a viscount. In the reign of Edward III. the use of ermine was restricted to the royal family, and even now that fur, under the name of "miniver," indicates the rank of the wearer according to the number of black spots with which it is adorned. In the same reign the use of furs was altogether prohibited to persons whose income did not exceed one hundred pounds a year. At this time and subsequently the right to trade exclusively in furs and to prepare them was conferred on the Skinners' Company.

It was, however, the discovery of the New World that led to the very general use of furs amongst European nations. In the northern parts of America the trackless forests and extensive plains abound in all kinds of hairy animals. We are indebted to the French colonists, who first settled on the banks of the St. Lawrence in Canada, for introducing furs from the New World.

They first bartered trinkets and other small manufactured articles for skins with the Indians of the district. Subsequently European settlers undertook expeditions in canoes laden with articles which they exchanged for skins. Many of these traders settled in the north, and thus there sprang up a regular trade in furs from this part of the world. In 1670 Charles II. chartered a society, called the Hudson's Bay Company, with the privilege of trading exclusively with the Indians who lived north and west of the bay from which they took their name. This company still exists; and from the nature of the charters which it has received from time to time from the English Government, it possesses almost absolute control over a district of the world more than half as large as the whole of Europe. Its extent is about 2,000,000 of square miles. It may be interesting to you to know how this vast country is governed. There is first a governor-in-chief. Under him are sixteen factors, controlling the large districts into which the whole territory is divided. Subordinate to these are twenty-five chief traders. These persons are not paid by salary, but receive a per-centage on the profits of the company. Under the factors and chief traders are five surgeons, forty chaplains or missionaries, a hundred and fifty clerks, and twelve hundred servants, The governor and factors constitute a council, through which the affairs of the company are transacted. There is also a board in London, from whom general instructions are issued. Besides this staff there are five hundred voyageurs who manage the canoes, and a multitude of labourers, fishers, and hunters. These are all Canadians, or Europeans, or half-breeds. It is, however,

the native Indians who destroy the animals. The time for this work is the winter, and they are then supplied with guns and ammunition, and bring in the result of their toil in the spring. They are then paid for the skins according to a fixed tariff, and which is made quite independent of their real value. The skins are often purchased by barter. Thus a fourpenny comb, it is said, will barter for a bear's skin worth two pounds. A knife worth sixpence will purchase three martens' skins, which in London will fetch four guineas; whilst a sea otter's skin worth fifty guineas is bought for about two shillings. These skins are bought by the company's agents, and are sold at the annual sales in London. These generally take place in March. The following table will give you some idea of the extent and value of the Hudson's Bay Company's transactions in skins:—

	No.	*Average Price.*		
Bear	11,870	£2	4	0
Beaver	82,830	0	9	6
Coney	142,285	0	0	4
Ermine	96,523	0	1	1
Fitch	158,955	0	2	8
Fox	81,487	0	11	10
Lynx	15,688	0	13	0
Marten	206,777	0	12	0
Minx	112,466	0	7	9
Musquash	1,190,430	0	1	2
Neutria	175,821	0	12	0
Otter	19,930	2	0	0
Racoon	490,128	0	4	0
Sable	844	2	10	0
Seal	681,234	0	5	0
Squirrel	2,188,737	0	0	4*

* English Cyclopædia, Article "Furs."

This is from the return for 1856; but of course these numbers will vary from year to year, and the prices with them.

The furs brought to this country, from whatever part of the world, are divided by the trade into felted furs and dressed furs. The felted furs are those which are used for hatmaking, whilst the dressed furs are those which are used for articles of dress and warm coverings. The felted furs are confined to a few animals which possess hair capable of felting. These are employed principally in hat making—such are the hare, the rabbit, the beaver, and the neutria. I told you in a previous lecture* that many other animals possessed hair that felted, and could be used for hatmaking. But the use of these furs for making hats is very much diminishing, as the silk hat is a much more economical article than the beaver one. In all cases where the fur is felted, it is first removed from the felt or skin; and this is a process requiring considerable care and attention. The skins used for felting usually present two kinds of hairs,—the one being long and possessing no felting properties, and the other short and felting easily. This latter is called the true fur. When the skin is destined for felting purposes the long hairs are removed by plucking out or very careful shearing. In the case of the beaver the long hairs are pulled by the knife and the thumb. These long hairs, being of no use to the hatter, are sold for stuffing chairs. The fur is afterwards cut from the skin of the beaver by the aid of machinery.

The preparation of fur for the purposes of dress is

* Lecture on "Wool," p. 38.

much more simple. The fur-hunters of America, when they have captured an animal, strip off the skin and hang it up to dry, either in the open air or in a room where there is no fire.

Great care is taken not to injure the skin, and also to prevent any portion from decay, for the slightest amount of putrefaction is attended with the loosening and falling off of the hairs. When the skins are dried they are packed up for exportation, but the furrier is very careful to ascertain that his skins are free from any spots of decay. The skins are then submitted to a variety of processes, for the double purpose of getting all the oil and fat out of both the skin and the hair, and of giving them durability and softness. In order to effect these objects, the skin is first softened by water. It is then greased and worked about over a stone with a blunt knife, and afterwards all the flesh is removed, and it is put into tanning tubs with mahogany and beech sawdust.

In preparing seal-skins, the oil contained in the fur is removed by the application of soap with the addition of soda. The skin is then washed thoroughly in cold water, and hung up to dry. Lamb skins are first soaked in cold water, and afterwards fleshed with a knife. They are then put into tubs, with alternate layers of bran moistened with salt and water. They are changed daily for a fortnight, and then dried. They are then heaped together, when they become moist. In this state they are drawn over a knife, and afterwards placed in a tub with hay seeds. During these processes the gelatine of the skin is converted into an insoluble and undecomposable substance, like leather.

It is on account of this fact that the furs of animals are so very durable as articles of wearing apparel. When thus dressed, the skins are ready for use. The furrier, however, in order to give the skins a uniform appearance, is often obliged to cut up a great many skins, and sew pieces together.

The keeping furs is a matter of considerable importance. So difficult is it to keep them from damp on the one hand, and insects on the other, that many persons send their fur clothing to be kept during the summer at their furrier's. This is done extensively in large establishments, like those of Mr. Nicholay in Oxford Street, and Mr. Roberts in Regent Street. The way in which they are preserved is to keep them in dry, cool rooms, and submit them regularly once in five or six weeks to a smart thrashing from a small switch or rod, or, what is better, a hatter's bow.

Having said thus much with regard to the history of the use and preparation of the skins, I will now draw your attention to the animals which supply them. We are indebted for furs to almost every tribe of animals that wear hair upon their backs, so that I may preface my remarks by presenting you with a classification of the mammalia, from nearly every group of which you will see that we derive skins for use.

CLASSIFICATION OF THE MAMMALIA.

SUB-CLASS I.—VIVIPAROUS.

1. *With hands.*

I. Bimana.—With two hands.
Example: Man.

II. Quadrumana.—With four hands.
Examples: Apes, Baboons, Monkeys.

2. *Without hands.*

A. LAND ANIMALS.

a. With claws or divided feet.

III. CHEIROPTERA.—Hand-winged.
Example: Bats.

IV. INSECTIVORA.—Insect-eaters.
Examples: Hedgehog, Mole, Shrew.

V. CARNIVORA.—Flesh-eaters.
Examples: Lion, Cat, Wolf.

VI. RODENTIA.—Gnawing animals.
Examples: Rabbit, Rat, Mouse.

VII. EDENTATA.—Toothless animals.
Examples: Armadillo, Sloth, Ant-eater.

b. With hoofs or united toes.

VIII. RUMINANTIA.—Ruminating animals.
Examples: Ox, Sheep, Deer.

IX. PACHYDERMATA.—Thick-skinned.
Examples: Elephant, Horse, Pig.

B. AQUATIC ANIMALS.

X. CETACEA.—Whale-like animals.
Examples: Whale, Porpoise.

SUB-CLASS. II. OVO-VIVIPAROUS.

XI. MARSUPIALIA.—Pouched animals.
Examples: Kangaroo, Tasmanian Wolf, Pouch-rat.

This classification is not perhaps the most philosophical or the most modern that could have been given, but it will suit my purpose here because of its simplicity. By taking into consideration the examples, there are few who will not be able at once to form some idea of the structure of the various orders of animals mentioned. From nearly all of them, with two exceptions, do we derive some of our furs. These exceptions are man and the whales. These creatures are smooth-skinned and afford no fur. It is, however, to the carnivora and rodentia that we are particularly indebted for the great bulk of the animals that supply us with skins for fur. In the list of imports from the

Hudson's Bay Company, which I referred to just now, you will find that all the animals belong to one or the other of these two orders. At the same time, any animal's skin may be worn, and we shall find that Fashion often determines what animal shall die to gratify its wavering modes. A good illustration of this is found in the first order of animals that I shall have to bring before your notice. Up to the time of the Great Exhibition of 1851, I believe I am right in saying that the skins of the monkey tribe had scarcely ever been worn. But at that exhibition some black monkey-skins, belonging to the genus *Colobus*, were shown, and unfortunately for that unhappy tribe of creatures, they excited the admiration of Mr. Nicholay, of Oxford Street. What beautiful muffs those skins would make! The thought soon led to action, and now annually there are imported to this country, from the forests of Africa, thousands and tens of thousands of the skins of these black monkeys. It is almost a painful thought when we consider how human these creatures are in their habits and affections, that each warm muff may have cost a world of suffering and anxiety amongst the surviving relatives of the original owner of the skin. At the same time there is a silver lining to this dark cloud of thought. The work of catching these monkeys is civilizing the African, and if he can sell his dead monkey skins to European traders, his temptation to sell his living brothers to American slave-holders is in that proportion diminished.

It appears that there are three species of black monkey which are brought into the markets for the purpose of affording the skin that is now so generally worn. They

have all long black hair, and all belong to the genus *Colobus*, and are all natives of Africa. The most common form is the black colobus, the *Colobus Satanas* of naturalists, named evidently from its supposed resemblance to his Satanic majesty. Another species also commonly imported is the white-thighed colobus (*C. leucomeros*). There is also another species, and perhaps the skins of even other forms might be found amongst them brought into the fur markets. These monkey-skins are bought of the natives on the west coast of Africa, Gambia, and Fernando Po.

There is also another monkey, brought from the same districts and used for the same purposes, known to furriers by the name of the grey monkey. This is no other than the Diana monkey, a graceful, active creature, often seen in European collections. It has a white mark on its head very like, in form, the semilunar symbol devoted to the goddess Diana: hence it has acquired its name. This monkey has grey hair on its sides, with a brown mark extending from the middle to the lower part of its back, so that it is easily known.

These two groups of monkeys afford an interesting illustration of the differences that exist between African monkeys. There is one group of them that have no thumbs on their fore-hands, and to them the colobuses belong, whilst the *Cercopithecus*, of which genus the Diana monkey is a species, have all of them thumbs.

The Quadrumana may be divided into three great groups—the apes, the baboons, and the monkeys. The apes have no tails, the baboons have short tails, whilst

the monkeys have long tails. The apes include the gorilla and the chimpanzee of Africa, and the ourang-outan and pongo of Borneo and Sumatra. The skins of these creatures are very valuable, but in a different way to those of which we have spoken. As illustrations for museums of natural history, the skins of all animals will always fetch a certain price. Of this we have had a proof in the prices which have been recently paid by the British Museum for the gorilla skins brought from Western Africa by M. de Chaillu. When we look at the specimen of the ourang stuffed by Mr. Bartlett, and deposited in the South Kensington Museum, we feel that these creatures are ministering to an art which keeps their living resemblance before us in a state resembling sleep. We step cautiously past this specimen lest we should wake it from the sleep in which it seems to be indulging. If the skins of these animals are valuable, how much more are their living forms. The fortunate traveller who should bring to England a live gorilla would undoubtedly make a small fortune, whilst great sums have been paid to those who have brought to Europe the chimpanzee or the ourang-outan.

The baboons are of less interest and value than the apes. They assume two distinctive forms, the one inhabiting Asia, the other Africa. They are of no further value than as specimens, alive or dead, in our zoological gardens or museums. The same may be said of the family of American monkeys, the Cebidæ, which have the power of using their tails as organs of prehension, of the little group of marmosettes, and of the lemurs from the island of Madagascar.

The Cheiroptera is the next group of animals which we come to, and here, however interesting the group is, on account of its presenting us with animals that fly and suckle their young, I must limit my remarks. The skin of the bat would undoubtedly be as useful as that of the rat, the mouse, or the mole; but as bats are much rarer animals, the price of their skins would not pay for their capture. Nevertheless, they are interesting in museums, and Dr. Carpenter says that the flesh of the frugivorous bats is eaten as a great dainty by the inhabitants of the countries in which they are found. Their flesh is said to resemble that of the hare or partridge.

The next order of the mammalia are the Insectivora, which have a close resemblance in general structure to the bats, but they have no wings. Some of the bats are frugivorous, but all, as their name implies, are eaters of insects. Of the more prominent forms of these animals, we have examples in England in the mole, the shrew, and the hedgehog. The skin of the two latter is not used by the furrier, but that of the mole might be employed extensively. It has a soft, black, shining coat, and although small, it is easily sewed together, and can be used for a variety of purposes. It is sometimes made into muffs, and also worn as trimmings. Sometimes the fur of this animal is entirely white, or it is yellowish or ash-coloured, or mingled with white and black. It does not seem to be generally known that the skins of this animal are of any value, or we should scarcely see so many of them hanging up, not as warnings to their blind brethren surely, but as trophies of the triumphant deeds of the rat or mole catcher. I

understand the furriers in London will give one shilling a dozen for any number of mole-skins properly dried.

The structure of this animal is singularly interesting on account of its wonderful adaptation to its peculiar habits. This is seen even in the skin, for the hairs of which its soft thick fur is composed are inserted vertically into the skin, so that they lie smoothly in every direction, and offer no resistance to the animal's backward and forward movements in its subterranean haunts. This animal is an expert digger, and has a wonderful development of its forearms for this purpose. It makes for itself a very complicated residence underground, the exact locality of which is easily detected by the heaps of earth it throws up from its underground tunnels. Its sense of hearing and smell are very aeute, and as it lives so much away from the light eyes would be of little use, and it has therefore very minute and feeble organs of vision. This beautiful little creature is persecuted with the most ferocious pertinacity by all who cultivate land, yet it is wrong to say that it does more harm than good. It destroys large quantities of the grubs of insects which would do great harm if they lived. It makes a piece of ground unsightly, to be sure, and occasionally taps a dyke in its tunnelling; but this is perfectly unintentional, and on the whole it is probable that man loses considerably by the costly and vindictive war of extermination which he carries on against this little animal.

I now approach a large order, and one on which I shall have to detain you some time. This is the Carnivora. It embraces the noble lion and tiger, the bear, the seal, the sable, and the ermine. Its species are the terror of

all other tribes of animals, and they are found alike in tropical forests, and amongst the everlasting snows of the high mountainous and Arctic regions. They are named from their habit of living on flesh. They are endowed with fierce propensities, and delight in living blood. They have sharp teeth with which to cut up their living prey, and lever-like jaws which move up and down with great precision. Their eyes are keen to discern their prey, and they have a great power of dissembling so as to lure their victims to destruction.

The carnivora are divided into three great groups according to the structure of their feet. The first embrace all those creatures in which the bones of the feet are so arranged that the animal rests on the tips of its toes, as in the case of the dog, the cat, and the lion. On this account they are called Digitigrade, or toe-walkers. The second division includes those animals which are so constructed that the whole foot is flat, and they walk upon their palms and soles. These are called Plantigrade, or palm-walkers. The third division are aquatic animals, and have their extremities adapted for an expansion of the skin or web by which they are enabled to swim with facility. They are called Pinnigrade, or fin-walkers.

The first family of the digitigrade carnivora is that to which the lions, tigers, and cats belong. The skins of these animals are prepared by the furrier, but they are not extensively employed. The lion (*Felis Leo*) although exhibiting great varieties, belongs to one species. It is entirely confined to the old world, and is found in the wild forests of Africa, in some of the districts of Arabia and Persia, and some parts of India. The

skin of the lion is chiefly brought from Africa, and of these scarcely a hundred are imported into this country annually.

The tiger (*Felis Tigris*) is exclusively an Asiatic animal. It is found in the south-eastern parts of Asia, and the islands of the Asiatic Archipelago. On account of its destructive habits it is a great pest to the districts in which it dwells. It is found in great numbers in Assam, where a reward of ten shillings is given by the Government for its head. As much as £1,700 have been given in this district alone in one season for tigers' heads. In consequence of this the skins are much more abundant than those of the lion. A tiger's skin can be bought for two pounds in the Cape colony, where they are brought from India. From two hundred to two hundred and fifty tigers' skins are annually imported into this country. They are used as rugs or mats, and for the covering of chairs. In China the mandarins cover the seat of justice with the skin of the tiger.

The leopard (*Felis Leopardus*) and the panther are so much alike that it is not easy to distinguish between them. They are natives of Africa, India, and the islands of the Indian Archipelago. The number of skins of these animals imported into this country seldom exceeds two hundred. The skin of the leopard is introduced under the saddle in some of the English cavalry regiments as a distinction of rank amongst the officers. In Austria the skin of the leopard is worn as a mantle by the Hungarian noblemen forming the Royal Hussar body-guard.

The Cheetah, or hunting leopard (*Felis jubata*), is an inhabitant of the East Indies, where it is trained to

several useful purposes. Its fur is not so smooth as that of other feline animals, and it is seldom seen in the fur markets of this country. This animal is to a certain extent domesticated in India, and is used for hunting purposes as we employ dogs.

The skin of the Puma (*Felis concolor*), or, as it is sometimes called, the American lion, is occasionally imported into this country. It is known amongst furriers as panther-skin, but this is evidently a misnomer. It is used in common with other skins for carriage wrappers.

The Jaguar (*Felis Oncar*) is one of the most beautiful animals of the family. From three to four hundred skins are annually imported into this country, and used as rugs, or for ornamental purposes.

The skin of the domestic cat (*Felis Catus*) is extensively employed by the furrier. The importation of these skins exceeds twenty thousand annually, whilst large supplies are afforded from native sources. The furrier recognizes the cat in two conditions—as the wild cat and the domestic cat. Considerable doubt has been expressed as to whether these two forms belong to the same species. There seems to be evidence that the wild cat lived in the forests of this country long before the domestic cat was introduced. Whatever be the origin of the domestic cat, we find it historically first amongst the Egyptians, who regarded it with religious reverence, and preserved it as a mummy in their tombs. It is a curious fact that there is no word for cat in the ancient Sanskrit, and it would appear probable that amongst the people who spoke this language the domestic cat was unknown. What is frequently called

the wild cat in this country is the domestic cat which has broken the restraints of civilization, and retired to forests in the neighourhood of man. One argument brought forward to support the view of the distinction of the two animals as species is the fact that these escaped cats never assume the characters of the true wild cat.

Both the wild and domestic cat are used for their skins. The wild cat has a longer fur and produces a more valuable skin than the domestic one. It abounds in the forests of Hungary, and is not unfrequently found in the uncultivated districts of Wales and Scotland. When captured alive it is found to be very untamable in its disposition, and in this respect differs from the domestic cat that has run wild.

In Holland the domestic cat is bred for the sake of its skin, which affords a most useful and durable fur. In order to improve its fur the cats thus kept are fed entirely on fish. Whether this is a delusion or not I cannot say. There are, however, many absurd notions afloat about what will make the hair smooth and soft: the hairdresser profits largely by these delusions. But there is one notion that prevails about these poor cats that ought to be exposed. It is a vulgar impression that if cats are skinned alive their skins are more valuable. Now I have the authority of both Mr. Roberts and Mr. Nicholay for saying there is not a particle of truth in this belief. They are not only utterly unaware of any difference between the skin of the cat when taken off alive, but they were never acquainted with a furrier who had thought of such a thing. Yet most assuredly it is a fact that there are wretches who,

acting on this impression, have skinned cats alive, and who have been brought before our public courts in consequence.

The cat's skin is made into a variety of articles of use. In the South Kensington Museum there is a rug of cats' skins, bordered with the skin of the black monkey. It is also employed for carriage wrappers, railway rugs, and sleigh coverings. It also makes a good rubber for electrical apparatus, and when kept dry is one of the most readily excitable of the non-conductors of electricity.

One of the last of the *Felidæ* which I shall have occasion to mention is the lynx. There are several species of lynx, each quarter of the globe having its representative. The species which supplies the European fur market is the Canadian lynx (*Felis Canadensis*). It is clothed with a very soft thick fur, and the colder the climate from which it comes the thicker the fur and the more valuable the skin. The Canadian lynx is a very common animal in the hunting-grounds of the Hudson's Bay Company, and as many as from fifteen to twenty thousand skins are sold at the annual sales of the company in London. The natural colour of the Canadian lynx is a light grey spotted with dark and rufous spots.

The next group of the carnivora is the dogs (*Canidæ*). It includes the dogs, the wolves, and the foxes. The skin of the dog is not valued on account of its fur; nevertheless some varieties of the dog are valued on account of their fur. There is no regular trade in dogs' skins, although in most collections of furs a few dogs' skins will be found in the form of some fancy article

of dress or utility. The wolf (*Canis Lupus*), which by some is considered the original of the dog, possesses a skin which is valued on account of its fur. It is one of the few large forms of the carnivora which have resisted the progress of civilization in Europe. It is entirely exterminated in the British islands, but it lingers in the forests of both the north and the south of Europe. It is indebted to its mingled cunning and cowardice for this immunity. It is abundant in Russia, in the northern parts of Asia, and in North America.

The European forms of the wolf are generally of a yellowish or fulvous-grey colour. The French wolves are generally brown and smaller than those of Germany, whilst those of Russia are larger, and have much coarse hair on the face and neck. In Sweden and Norway the wolves resemble those from Russia, but are lighter in colour, and in winter they become perfectly white. The Alpine wolves again are small and of a brownish grey colour, whilst those of Italy and Turkey are brown. From nine to ten thousand wolf-skins are annually imported into this country from Europe, the United States, and British North America. They are used for the linings of coats and cloaks, for sleigh coverings, and other purposes where warmth is required.

We now come to speak of the family of foxes (*Vulpidæ*), of which more skins are brought to Europe than of any animals I have before mentioned. The foxes are generally known by their long sharp noses and their bushy tails. The common fox (*Vulpes vulgaris*) is a native of Great Britain. It would, however, have been long since extinct in this country, but that it is artificially maintained for the sake of the cruel amusement

of hunting it. For this purpose dogs are kept whose sole object is to hunt this creature. The fox is, however, a very destructive animal, and its pursuit is not less so, and in a highly cultivated country like Great Britain such an amusement is open to the charges of both cruelty and extravagance. It is not, however, the common fox of Europe that is found in the furriers' shops, but the various species of American fox. These are known better by the colour of their skins than by their specific names. Thus, there is the red fox, the grey fox, the white fox, the blue fox, the cross fox, the silver fox, and the kitt fox.

The red fox (*Vulpes fulvus*) of North America was at one time considered identical with the common European fox. It differs, however, from the latter animal, and is much more easily taken in the chase. It is of a ferruginous colour, and its skin is much sought after for employment in various manufactures. About 8,000 skins of this animal are annually imported into this country, but the principal part are re-exported and find their way more especially into the markets of Turkey. The cross fox, which is distinguished by a black cross on the neck and shoulders, is a variety of this species, and sells for as high a price as four or five pounds.

The black, or silver fox, is also a variety of the same species. It is known by its intensely black skin, which is often mingled with silvery hairs, and a white spot at the end of its tail. An unusually fine skin of one of these animals has been sold in London for £100. The imperial pelisse of the Emperor of Russia, made of the black necks of the silver fox, and which was exhibited at Hyde Park in 1851, was valued at £3,500.

The white fox is the Arctic fox (*Vulpes lagopus*) in its winter dress. This is a small species of fox found in great numbers within the Arctic circle. It is free from smell, and easily tamed. There is a dark variety of this fox known as the sooty or blue fox. Both the blue and white skins are brought into this country in very considerable quantities; but they do not fetch the same price as the red fox. The blue or sooty form of this animal is sometimes called *Vulpes fuliginosus*.

The grey fox (*Vulpes Azaræ*) is brought from the Southern States of America, and although imported in large numbers is less valuable than the other species. Its fur is white, red, and black, hence it is called in France *Le Renard tricolor*.

Another species of fox, whose skin is used in large numbers in Russia, is the Cossac (*Vulpes Cossac*). It inhabits the vast plains of Tartary. It is of a clear yellow ferruginous colour, and in winter it is mixed or shaded with grey-white on the belly. Not fewer than from forty to fifty thousand skins of these animals are taken annually. They are chiefly disposed of in Russia and Turkey.

The next group of Carnivorous animals used for their fur is the *Mustelidæ*. This family includes the fitch or polecat, the musk, the sable, the ermine, the weasel, the wolverine, and the skunk. They are not such formidable creatures as the preceding; they are, nevertheless, equally sanguinary in their propensities, and destructive of the life of the smaller mammalia, birds, and fishes. They have generally short legs and an elongated body, and from their appearance and movements they have been called vermiform (worm-like)

carnivora. Many of them give off an offensive odour, nevertheless they yield some of the most costly and prized of furs. One of the most valued of these is the Russian sable. The animal which yields this fur belongs to the same genus as the various species of marten, whose skins are brought into this country in immense numbers from North America. Up to the present day it does not seem determined absolutely as to whether the *Mustela zibellina* of the furrier is truly a distinct species. The fur is, however, well known and easily distinguished. The animal which yields it lives in the wilds of Siberia, and its pursuit is represented as one of the most painful and arduous which the hunter in these regions has to endure. Its fur is most valued when taken in the depth of winter, and it is at this season of the year the hunter pursues his prey. Although the skins are small, they are sold at prices varying from three to ten guineas. But, comparatively, few of these precious skins find their way to this country, as they are highly valued in Russia. It is calculated that twenty-five thousand skins are annually sold in Russia, whilst about two thousand are consumed in England. The fur is usually manufactured into linings, and in this form they are presented by the Emperor of Russia, the Sultan of Turkey, and other great potentates. These linings are sometimes valued at as high a price as one thousand guineas. The lord mayor, aldermen and sheriffs of the city of London have their robes and gowns lined with the fur of the sable according to their respective ranks. The tail of the sable, as of many other creatures, has its independent uses. Thus, it is made into trimmings of various kinds, and also

muffs and boas. The artist is also indebted to the tail of the sable for some of his most delicate brushes.

The next most interesting creature in this family is the ermine (*Mustela erminea*). Although known for its beautiful white fur with a black tail, this is only the winter dress of the animal. In the summer it assumes a brown garb, and is identical with the animal known in the British islands as the stoat.

There is something very curious in the fact, that many animals grow lighter in colour in the winter. If this was general one would be inclined to regard it as a provision for keeping the animal warm, as we know that white is warmer in the winter as well as cooler in the summer. Be that as it may, it is the white coat of this animal which is so highly valued. The ermine is procured in most countries in Europe, but the best skins come from Norway, Sweden, and Russia. The ermine is the royal fur of this and many other countries. The Roman pontiff and cardinals have their ecclesiastical robes adorned with capes and trimmings of ermine according to their rank. In England the ermine is studded with black spots, which are made of the skin of the black Astracan lamb. It is then called "miniver," and the arrangement of the black spots indicates the rank of the wearer. The sovereign and the members of the royal family have the miniver of the coronation robes powdered all over, a black spot being inserted in every inch of the fur. The crown is also adorned with a band of miniver, with a single row of spots. The coronets of peers and peeresses have also a similar decoration. On state occasions in the House of Lords, the peers are arrayed in their robes of state of

scarlet cloth and gold-lace, with the characteristic bars or rows of pure miniver. The judges are clad in scarlet robes with pure ermine.

The ermine, with the black tail of the animal inserted in it, is used also for every article of ladies' dress, muffs, tippets, trimmings, and linings. In the reign of Edward III. furs of ermine were strictly forbidden to be worn by any but members of the royal family. Its general use is prohibited in Austria even at the present day. Miniver is not allowed to be worn on state occasions in England by any but those who on account of their rank are entitled to its use. The number of ermine skins imported annually into this country is upwards of 100,000, and of these very few are re-exported.

The Minx (*Mustela vison*) is the next animal of importance in this group of little vermiform flesh-eaters. It is a native of North America, and its skin comes to us principally through the Hudson's Bay Company. The fur of this animal resembles that of the sable, but it is shorter and more glossy. It is used especially for ladies' wear, and is made into victorines, cloaks, muffs, and all sorts of fur clothing. There is an increasing demand for this skin, and as much as from ten to fifteen shillings are given for a skin. It is much used in America. As many as a quarter of a million of these skins have been brought into this country in a single year. Sometimes this skin is of a silver-grey colour and of great fineness. A muff made of six of these skins is sold for twenty-five guineas.

There are several species of *Mustela*, whose skins are brought into the markets of this country under the

common name of Marten. The number of marten-skins imported into Great Britain in 1856 was 206,000: of these the greatest number belong to the *Mustela leucopus*, or American sable: it is known by its white feet. The fur varies from a tawny colour to a deep black. These last are most valued; hence the lighter ones are frequently dyed so as to imitate the darker skins. The fur of this animal is more worn in England than any other, and is made into cuffs, muffs, and boas.

The Woodshock or Pekan (*Mustela Canadensis*) comes into this country under the name of the Fisher, and is also called Pennant's marten. The fur is long, fine, and lustrous, lighter in colour than the Russian sable, and is often dyed to imitate it. About 18,000 skins are annually imported.

Besides these two of American origin, the Pine marten and the Stone marten are both used for their skins. These animals are found in Europe. The Pine marten (*Mustela Abietum*) is found in the northern parts of Scotland; it is also found in Germany, where it is called the Barn marten. It lives in deep forests, shunning the habitations of men. It is something like the Beech marten (*Mustela foina*), which is also an inhabitant of Great Britain, and is known by its white throat. It is found in woods and forests, but nearer the habitations of men than the Pine marten. The Stone marten (*Mustela Saxorum*) is found in rocky districts and amongst the ruins of old buildings. It is not found in Great Britain, but abounds in some parts of Europe. It is very much admired for ladies' dresses. It is sometimes worn of its natural colour,

but is more frequently dyed: it is then sold under the name of French sable.

These are the different forms of marten sold in the furriers' shops. It is, however, frequently very difficult to make out to what animal a particular article of dress belongs, or even a prepared skin, from the fact that the most characteristic parts of the animal are removed in the preparation of its skin.

Another form of the genus *Mustela* is the polecat or fitch (*M. putorius*). This is one of the largest creatures of the tribe. The hair upon the skin is of two kinds—the one short, brown, and woolly; the other long, black, and shiny. At one time the fur of this animal was the most fashionable worn; it is, however, one of this tribe of animals which emits an unpleasant odour, and which has got for it the appellation of the "foumart," a corruption of foul marten; and perhaps owing to this cause it fell into disuse. Recently, again, it has come into use as processes have been applied which remove from it the objectionable odour. It is an inhabitant of Great Britain, where it does great damage in the farmyards. It is hunted in various parts of Europe, and the immense numbers in which it exists is attested by the fact that from 150,000 to 200,000 are annually sold in the fur-markets of London. The finest specimens of the skin of this animal are obtained in Scotland. Upwards of 25,000 of these skins are annually sent out of Great Britain principally to America, where this fur is much sought after.

In the northern parts of Russia and in Siberia, a little animal is caught, and the skin of which is called

by the Russians Kolinski, or chorok (*Mustela Sibirica*). The fur is of a bright yellow colour, having no difference of shade in any part of the body. It is used both in its natural state and dyed. The tail is employed for artists' pencils. In 1856, as many as 70,000 skins of this animal were imported into this country.

To the genus *Mustela* several other animals belong, with which we are more or less acquainted, but which are not commonly employed by the furrier. The common ferret is the *Mustela Furo,* and is very valuable on account of its hunting habits, and is used for the destruction of rats, rabbits, and mice. The common weasel (*Mustela vulgaris*) may be taken as the type of the group.

The last animal of this tribe we need to mention is the Skunk (*Mephitis Americana*). This animal is known above all others of its tribe for the abominable stench it gives out when hunted. This is sometimes so strong that neither hunter nor dog can endure it. Nevertheless it can be purified by exposure to heat; and although, generally, it has a long coarse hair, some specimens have a fine fur equal to that of the silver fox. It is much used in Germany and America. The Hudson's Bay Company now annually import about 10,000 skins, which are mostly reshipped for other parts of the world.

The Otter (*Lutra vulgaris*) is one of the larger forms of this group of carnivora which still lingers in this country. It is aquatic in its habits, and lives principally upon fish which it pursues in the water. It has been tamed and employed for the purpose of catching fish. About 500 otter-skins are sent into the markets

from the British isles alone. It is, however, the American otter (*Lutra Canadensis*) which supplies the fur-market with its skins. The average number of otter-skins annually purchased at the fur sales in this country is about 20,000; of these, 16,000 are again sold to foreign markets. The fur of this animal resembles that of the beaver, but is shorter, and consequently not so well adapted for felting. The colour and quality of the fur vary much with the season; in summer, when the hair is very short, it is almost black; but as the winter advances, it turns to a beautiful reddish brown.

The sea-otter (*Enhydra marina*) is a different animal, and brings us near to the seals. It is entirely aquatic in its habits, and is found in the North Pacific, from Kamschatka to the Yellow Sea, on the Asiatic coasts, and from Alacka to Chili on the American coast. It is a rare animal, and not more than a thousand skins are annually procured. They are highly prized in Russia and China, and in both countries they are used as the royal fur. It is employed for collars, cuffs, and trimmings generally. The fur is very beautiful, consisting of fine jet-black hairs, about three quarters of an inch in length, and having a silvery appearance at the tip of each hair. In older specimens many of the hairs become white. A fine skin of the sea-otter is worth as much as forty pounds, and a muff of this skin costs about twenty-five guineas.

I must pass over the next family—the hyænas, whose skins are not in request,—and come to the Plantigrades, the flat-footed carnivora. Here we meet with our old friends the bears. Bear-skins are highly valued, and upwards of 12,000 bears are annually sacrificed to

supply humanity with an extra covering. Bears are met with in Asia, America, and Africa; but America supplies us principally with bears. We use white-bear skins, brown-bear skins, black-bear skins, and grisly-bear skins. These are all distinct species.

The White Bear (*Thalassarctos maritimus*), which was not known as a distinct species in the time of Linnæus, is an inhabitant of the dreary regions which surround the North Pole, where frost eternally reigns, and the rocks are covered with enduring ice. Here it obtains a precarious subsistence by fishing in the sea, and clambering over the rocks in search of the eggs and young of sea-birds. Its existence even in these shivering latitudes is not useless to man. Many of the Greenlanders entirely clothe themselves with the skin of this animal. They make of it coat, trowsers, boots, and gloves. They use it indoors for seats and beds. In fact, to the human denizens of the Arctic regions it is one of the most important articles of utility. They dress the skin by pinning it down to the snow, and leaving it to freeze; after which the fat is scraped off. It is then exposed to the intense frost, and by the aid of a little scraping and manipulation, it becomes perfectly supple, both the skin and the hair being perfectly white. It is only occasionally used in this country.

The Brown Bear (*Ursus arctos*) was at one time undoubtedly an inhabitant of the British islands. Long after its extinction as a native of our forests, it was imported for the purpose of bear-baiting. This amusement has now, however, gone the way of nearly all those sports which were handed down to us by the necessities of our ancestors. The brown bear is found at the present

day in the mountainous districts of Europe, from high latitudes in the north, to the Alps and Pyrenees in the south. It is also found in Siberia, Kamschatka, and even Japan, to the eastward, and in portions of the northern regions of America. It is of various colours—brown, black, grey, and even white.

The Black Bear (*Ursus Americanus*) inhabits every wooded district of the American continent, from the Atlantic to the Pacific, and from Carolina to the shores of the Arctic Sea. The skin of this animal is brought to this country from British North America. In 1803, no less than 25,000 were imported. The number now annually brought here does not exceed 10,000, and of these about 8,000 are re-exported. It is used principally for military purposes, such as for caps, pistol-holsters, rugs, &c. It is hence often called the army bear.

The Grisly Bear (*Ursus ferox*) is the largest of the family. It inhabits the Rocky Mountains, and is occasionally imported into this country. All the bears, in fact, yield skins which may be employed for the same purposes as those I have mentioned. They make most comfortable and useful articles of wearing apparel for winter, and are extensively employed in Russia and other northern countries. They are not now so fashionable in this country as they were formerly.

Belonging to this group of carnivorous animals, is the Raccoon (*Procyon Lotor*). It is a native of the northern parts of America. It frequents the margins of swamps and rivers, and the sea-shore, and preys upon small animals, birds, insects, and mollusca, with the addition of roots and succulent vegetables. It climbs

trees, and, when taken young, is easily tamed. Upwards of half a million of the skins of this animal are imported annually into this country. Two-thirds of this number are re-exported, principally to Germany, where they are used for making hats. The hair of the upper part and sides of the body is of uniform length and colour. It is rather crisp, but tolerably soft. It is used for the linings of coats, for rugs, and other useful purposes.

Another group of the Plantigrade Carnivora is the Melidæ, which includes two animals of considerable importance to the furrier; that is, the Badger (*Meles vulgaris*) and the Wolverine (*Gulo luscus*). About 5,000 skins of the badger are annually imported into this country by the Hudson's-Bay Company. The species of badger obtained from North America is larger than that which inhabits the British islands. The skin of both is used for the same purposes. The long hairs are employed for making painters' pencils and shaving-brushes ; the finer skins are made into muffs and carriage-wrappers.

The Wolverine is also a North-American animal, and is known by the names of the Glutton, the Cavcajou, and the Quickhatch. The fur is of a fine deep chestnut colour, with a dark disk on the back. It is not a very abundant animal, only about 1,000 skins being annually imported into this country. It is used in Germany and Russia for muffs, cloak-linings, and sleigh robes.

We now pass on to the Pinnigrade Carnivora. These creatures are known by the common name of Seals. There are, however, a great variety, and, according to their fancied resemblances to other animals, they are known by the name of sea bears, sea cows, sea elephants,

sea leopards, and the like. They are mostly inhabitants of the colder regions about the Arctic and Antarctic circles. Several species are either constant or occasional inhabitants of the northern shores of the British islands. They are all adapted for living constantly in the water, and are awkward, ungainly creatures on the shore. Their structure is admirably adapted for their aquatic existence. Their fore and hinder extremities are very short, and separate bones of the feet are inclosed in an arch, so as to give them great facility in swimming. They are of chief importance to the inhabitants of Greenland, who eat their flesh, and use their fat both for lamps and fires. They clothe themselves with seal skins, and sew their garments with fibres of the same. Their canoes are covered with the same substance. The stomach and bowels are used as flasks, curtains, and shirts. In fact, no part of the seal is unused by the Greenlander. Great as is the necessity of the seal for their home use, they barter it for other articles; and from Greenland and other parts of the world we import annually upwards of 600,000 seal-skins. Most of these are used, as I have said, for leather; but a large number are dressed by the furrier, and used as articles of clothing. Caps and hats, mantles and muffs, coats and boots, are made from the skin of the fur seal. When the skin of this seal is imported, it is covered with long hairs, which lie smooth upon the back and conceal the short hair beneath. The long hair, which is planted very deep in the skin, is removed by soaking and shaving; thus leaving the fine silky fur beneath. This fur is sometimes worn in its natural colour, but it is more

frequently dyed of a dark hue, when it assumes a beautiful velvety appearance.

Seal skins are imported into this country without any distinction of species, and the following list of returns will give you an idea of the countries from which they come, as well as the value of this animal from a commercial point of view.

Russia	8,883
Norway	18,280
Denmark	23,240
Hanse Towns	41,339
Holland	65,149
United States	41,364
Uruguay	17,032
Greenland and Davis' Straits ...	87,053
British North America	371,275
Other parts	7,619
	681,234

Of these not more than 3,000 or 4,000 are sent away to other countries. Large as is this consumption, it has considerably fallen off within these last few years, as many as from 1,200,000 to 1,500,000 having at one time been imported in the course of a single year.

Although there are a great number of species of seal, those which are ordinarily used belong at most to four or five species.

The Common Seal, or sea-calf (*Phoca vitulina*) of the British islands is still hunted in Scotland for the sake of its skin. It is also found on the French coasts and other parts of Europe. Its fur is used especially for coat-linings and boots. This animal supplies by far the larger quantity of seal skins used in this country. The harp seal, or Greenland seal (*Phoca Græn-*

landica), is a larger seal than the last, is of a greyish-white ground colour spotted with black, and has a black face. It is occasionally found on the British coasts, but is the true seal of the Greenlander. It is also found on the coasts of Iceland and Newfoundland. The crested seal and rough seal (*Phoca cristatus* and *hispidus*) are also found on the coasts of Greenland and North America down to the United States. The skins which are brought from North America and the United States belong chiefly to these two species.

The Fur Seal (*Phoca Falklandica*) is found in the South Seas; it is also imported in considerable quantities from the United States and the west coast of America. It is called the fur seal to distinguish it from the other species which are called hair seals.

We must now leave the carnivora, and, passing over the groups of aquatic mammalia, which embraces the whales, the porpoises, the dugongs, and the manatees, and which afford no fur, we arrive at the little gnawing, quick-breeding order of Rodentia. These animals, though small, make up for their size by their numbers. Some of them, as the squirrels, supply millions of skins in the year to enable us to make ourselves warm and comfortable in the winter season of the year. You must also recollect that, prodigious as are the numbers of these creatures that are brought to this country in the course of the year, they do not at all represent the consumption of animals by man for clothing purposes. When we reflect upon the probable numbers of wild animals thus consumed and the occupation thus given to thousands of people, it must exalt in our minds the importance of these wild creatures to man.

The little gnawing rodents are distinguished in their structure from the carnivora by the absence of canine teeth and in possessing two large cutting teeth which project from the front of each jaw. These teeth enable them to gnaw through tough vegetable substances on which they subsist or which may present obstacles to their progress. They are enormously productive, hence the number and cheapness of the furs which these animals produce. I have before spoken of the Beaver (*Castor Fiber*), which is one of the largest animals belonging to this order. It is exceedingly interesting in its habits, building its house on rivers and marshes with great engineering skill and industry. One of these creatures may be seen daily at work in the Zoological Gardens, Regent's Park. The skin of the beaver was formerly much used for making hats on account of the facility with which its hairs could be felted. It is, however, comparatively little used for that purpose at the present day; but by an ingenious process, adopted by Mr. Roberts, the long upper hair of the beaver skin is cut off, and a beautiful short fur below is exposed, which renders it a very acceptable addition to the various furs that are employed for coat-linings, muffs, and other articles of dress. The beaver is abundant in Europe, but the greater number of the skins, amounting to about 80,000, imported into this country, are brought from North America.

In company with the beaver, and inhabiting the same districts, having also the same habit of building a house, is found the Musk-rat, or Musquash (*Fiber Zibeticus*). It is not so large as the beaver, but its hair very much resembles beaver fur, and is used for the same pur-

poses. Above a million of the skins of this animal are annually imported into this country, but large numbers of them are re-exported. They were formerly used for making hats, but are now dressed in the same way as beaver's skin, and form a cheap and durable fur for ladies' wear.

The Nutria, or Coypu (*Myopotanus Coypu*), is another rat-like animal, which inhabits South America. It has a fur intermediate between the beaver and the musquash; it is dressed in the same way, and used for the same purposes as these animals. In some years as many as a million of the skins of this animal have been sold in the fur marts of Great Britain.

The little family of Squirrels is laid under enormous contributions for the fur-market. Of all the sufferers of this tribe the common squirrel (*Sciurus vulgaris*) is the greatest. This active pretty little creature abounds in almost incredible numbers in the forests of Russia. It is said that from fifteen to twenty-three millions are annually killed there. The annual imports into this country amount to upwards of 2,000,000. The fur is used entirely for ladies' and children's wear. The celebrated Weisenfels linings are made from the white fur of the belly of this animal. It is remarkable for its lightness, a full-sized cloak-lining weighing only twenty-five ounces. It is known by the name of the *petit gris*. The white fur of the squirrel was formerly employed in the manufacture of minever. The fur of the squirrel is often dyed, so as to resemble sable. The tail is used in making boas, and also for artists' pencils.

Squirrel fur is known in the trade under the name of "calabar." Besides the common squirrel, the grey (*S.*

cinereus), the black (*S. niger*), the fox (*S. Carolinensis*), and the American red (*S. Hudsonius*), are brought from various parts of the world, and yield useful and ornamental furs.

Next to the squirrel in point of interest and importance we must place the Chinchilla (*Chinchilla lanigera*). This little rodent is a native of South America, and inhabits the valleys of the high mountain ranges where the cold is considerable. The colour of the fur is peculiar, being of a clear grey on the top of its back, passing gradually into a white underneath the animal. The fur is remarkably close and dense in its texture, and is on that account much used for muffs. It is also employed for mantles, boas, linings to cloaks, trimmings, and other purposes. These furs reach us entirely through the South American markets. There is, however, a great difference in quality; the skins imported from Lima having a shorter fur, and are generally inferior to those obtained from Buenos Ayres, Arica, and other districts of South America.

The next important group of rodents are the Hares and Rabbits. The English rabbit (*Lepus Cuniculus*) yields a very valuable fur, both in its wild and domesticated conditions. It produces a hair that felts; and when beaver hats were worn, it was extensively employed for making the foundations for these hats. It is, however, now dressed and dyed and used for making all sorts of cheap and warm articles of wearing apparel. A piece of felt cloth made from the hair of the rabbit is exhibited in the South Kensington Museum. It is very fine and light, and shows to what purposes the hair of this animal may be put.

Rabbits are of all colours, black, and white, and brown, as well as grey. The English silver-grey rabbit is a breed peculiar to Lincolnshire. Warrens have been established in that county for the purpose of breeding. The fur is not used in this country, but is principally exported to China, where it fetches a high price. With the sea otter it forms one of the imperial furs. There is a white variety of rabbit brought from Poland, which is used extensively for cloak-linings, and is one of the cheapest furs used for that purpose. The finer varieties of white rabbit skins produced in this country are used as substitutes for ermine, and it requires a practised eye to detect the difference. So late as the reign of Henry VIII., the skin of the white rabbit or cony, as it was called, was only worn by nobles and gentlemen; and Acts of Parliament still exist, giving regulations as to their use, but, of course, they are not attended to.

The skin of the Hare (*Lepus timidus*) is used for the same purposes as that of the rabbit. Its great use, however, is for wearing over the chest as a protection against external cold. I am not aware that the fur of the hare is more beneficial for this purpose than that of any other animal, but its warmth and small cost adapt it for this purpose better than the more expensive skins. There is a white species of hare, the Arctic hare (*Lepus glacialis*), which is white underneath; and this part of the skin is made into muffs and boas, whilst the back is used for linings and felting.

The native supply of rabbits and hares' skins is very large, amounting probably to many millions in the course of the year. Upwards of 1,000,000 of rabbits

are annually sold in Leadenhall and Newgate markets alone. The rabbit warrens of Norfolk produce hundreds of thousands annually; they are also brought from the Orkney and Shetland islands, and from Ostend. Upwards of a quarter of a million of hare skins are annually imported into this country from various parts of Europe.

There are many of the smaller rodents whose skins are used occasionally as furs. The Alpine Marmot (*Arctomys Marmota*) is common in Europe, and its skin is sometimes used by the furrier. The Quebec marmot (*Arctomys Empetra*) is also imported into this country under the names of the white and grey weenusk.

The order *Edentata* to which the Armadilloes, the Ant-eaters, and Sloths belong, afford no skins that are employed by the furrier; they are, however, a highly interesting group from a natural-history point of view, but I must not dwell on them. Nor need I detain you here upon the large groups of ruminant animals. I have spoken of the use of the hair of the sheep, in the form of wool, and also of the uses to which the skins of this order are put in the manufacture of leather; nevertheless some of them are prepared by the furrier for dress. The skins of the buffalo are dressed with the hair on, and under the name of "buffalo robes" form an admirable protection against cold.

The Bison (*Bison Americanus*) lives in prodigious herds in the far west of North America, and hundreds of thousands are annually killed on the plains of Missouri. About 150,000 skins find their way to the fur stations of America, and of these about 70,000 are

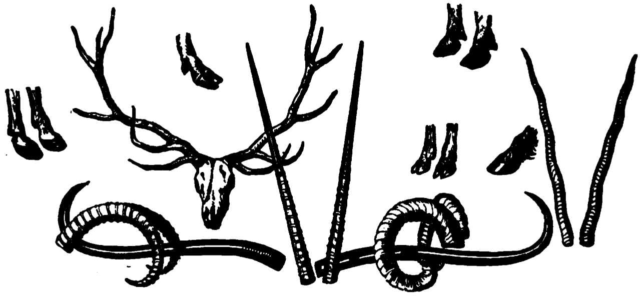
made up and sold as buffalo robes in New York. During the Crimean war our government supplied the army with 20,000 of these buffalo robes, and I know from good authority that many of our soldiers slept in them and attributed their immunity from disease to these robes.

The skin of the Lamb is employed for making glove linings, coat linings, collars, muffs, and trimmings. The most valuable of these skins are brought from Russia, Hungary, and Astracan. The Astracan lamb has a rich, glossy, black skin, with a short fur. The national coat of Hungary is made of the lambskin. The Spaniards also wear lambskin jackets. The Persian lambskins are also used for coats and other garments; they are known by the minute curls which the hair assumes. This is produced artificially by tyeing up the lamb as soon as it is born in a leathern skin which prevents the curl from expanding. In the reign of Richard II., the serjeant-at-law wore a robe lined with white lambskin, and a cape of the same.

The skins of the various species of Deer, though brought into this country in large quantities, are not employed by the furrier, but the tanner. So with the Pachydermata. The only order to which I have to refer is the *Marsupiala*, or pouched animals. We imported into this country in 1856 above 3,000 kangaroo-skins. They are principally used for making leather. Nevertheless, they might be employed for the sake of their fur, were not our supplies sc extensive from other members of the animal kingdom.

I must now conclude this rather long discourse on animals used for their fur. In doing so I hope I have

succeeded in interesting you in these higher animals, not only as sources of comfort and commerce, but as objects worthy of study, both for their own sakes, and the importance of their uses in relation to man. Whilst pursuing these interesting creatures for the sake of their valuable products, we should remember how largely they suffer for our benefit, and that all unnecessary pain in their pursuit and capture should be avoided. It is also a question of high interest to determine how far the enlightened governments of the world should interfere to prevent the unlimited destruction of animals which being once destroyed can never be restored; for whilst on the one hand, it is injurious to the interests of mankind for governments to interfere with trade and commerce, it is nevertheless a most important function of the civil power to prevent the selfishness of the few from interfering with the interests of the many.



ON FEATHERS, HORNS, AND HAIR.

In previous lectures I have spoken of the skin and its appendages, and I have also spoken of their structure. In speaking of leather I drew your attention to the glandular structures of the skin; in the lecture on wool I pointed out the way in which hair is produced as well as scales, feathers, horns, and hoofs; and in the last lecture I gave you an account of the uses of skin and hair in the form of furs. It is now left, then, for me to speak of the uses of those appendages of the skin which, not being wool, are used independently of the skin on which they grow. This will embrace a consideration of the uses of the scales of fishes, the feathers of birds, the shells of turtles and tortoises, and the hair, bristles, quills, hoofs, and bones of the mammalia.

The fish class is of more importance to man as food than in any other relation. We have seen, however, that the skins are gelatinous and are used on this account; that the bones contain phosphate of lime, and are valuable as a manure, and that oil is yielded by large numbers. The use of their scales is a very limited one, but still interesting as indicating that probably all parts of organic beings may be successfully applied to meet the wants of man. In my lecture on shells, I gave you an account of pearls, but I did not mention the fact that they are successfully imitated by the aid of fishes' scales. At a very early period beads were manufactured to imitate the opaline appearance of pearls. They were made of glass, hollow in the interior, and filled with a pearl-coloured pigment. About the year 1656, a Frenchman observed on his estate near Passy, that when the fish called bleak were washed the water was filled with fine silver-coloured particles. Having experimented upon the scales of this fish, he found he could collect this opalescent matter, and proceeded to use it for the purpose of manufacturing artificial pearls. Having found this to succeed, he manufactured this substance and sold it under the name of essence of pearl or *essence d'orient*. At first he made small beads of gypsum or hardened paste, and covered them with the essence of pearls, but when they got worn the pearly layer broke off. Hence he was induced to introduce his essence into the interior of a very thin glass bead which answered perfectly well. These glass beads are made in a peculiar way, and of all shapes and sizes, so as to imitate natural pearls. The pearl essence is introduced into

the interior of the glass bead by being mixed with a solution of isinglass which is heated, and when in a liquid state it is blown into the interior of the glass bead. The liquid is diffused over the interior of the beads by placing them on a heated moveable slab, which on being shaken causes the fluid in the interior to be spread all over the bead. After this process is over, the beads are filled with wax in order to give them solidity and strength.

The nacreous substance which produces this effect is found on the inner side of the scale of the fish, and gives to them the bright lustrous appearance they possess. It is found not only on the bleak, but in a large number of our fresh-water fish, and has been obtained from the scales of roach, dace, carp, and white-bait. Mr. Yarrell says, the white-bait yields a superior article to the bleak. But then white-bait are worth more to eat, and we swallow fish bones, essence of pearl, and all in that process. At one time the use of these ornaments was so general, that a quart of fish scales has been sold for five guineas. It takes, however, a great many fish to provide a quart of scales.

The Bleak (*Cyprius Alburnus*), is very common in the Rhine, the Moselle, the Seine, the Loire, and other rivers of Europe. It is also found in the Thames, and the Lea, and the New River. I have taken it in great numbers near Doncaster in Yorkshire, and it is probably very generally found in company with roach and dace.

It is very difficult sometimes to distinguish these pearls from real ones, and a story is told that, when

first introduced into France, a poor marquis who was enamoured of a lady and gained her affections, carried his point by a string of these pearls, which cost him about five pounds. The gift was regarded as one worth not less than a thousand pounds. This art of manufacturing pearls is confined to the French, and it appears that, up to within the last few years, the manufacture was carried on in Paris by the descendants of the original discoverer, Jaquin.

Not only is this nacreous lustre used, but the scale itself is employed in the manufacture of articles of ornament. At the Crystal Palace is a stall, where all kinds of articles for personal adornment are sold which are made out of prepared fish scales. They have a pearly appearance, and are put together in various forms, being considered exceedingly valuable.

From the fishes, we pass on to the Reptiles. This class of animals is divided into the following groups or orders:—

1. AMPHIBIA.—In which the animal leads part of its life in the water, and then breathes by means of gills. It includes the Toads, the Frogs, and the Newts.

2. OPHIDIA.—Distinguished by the absence of extremities. It includes the animals known as Serpents and Snakes.

3. SAURIA.—With four limbs, and body covered with scales or bony plates. In this order are included the Crocodiles, Alligators, Lizards, and Chameleons.

4. CHELONIA.—In which the bones of the thorax unite with the skin and form a kind of box which covers over and protects the hind parts. The Tortoises and Turtles belong to this order.

Of these groups of animals the last is the most

useful to man. A species of frog is eaten on the continent of Europe, and in former times the poison of snakes and their excretions were used in medicine. Crocodiles' eggs are regarded as a delicacy in Egypt, and lizards are eaten by the natives of Australia. But it is the Chelonia which yields us one of the most delicious kinds of diet, and the most prized of horny materials for articles of ornament. The chelonia are divided into five families:—the Land Tortoises (*Tèstudinidæ*), the Marsh Tortoises (*Emydidæ*), the Frog Tortoises (*Chelydidæ*), the River Tortoises (*Tryonycidæ*), and the Marine Tortoises (*Chelonidæ*). With the particular species belonging to each of these families, most persons are more or less familiar. Thus the common tortoise, which is best known, and which often becomes amongst us a kind of domestic pet, belongs to the first family. It is a native of the continent of Europe, and its natural history has a classical interest, from its habits having been recorded with so much accuracy and simplicity by White of Selborne. Of another member of this group, Mr. Darwin has made us acquainted in his charming "Voyages of a Naturalist." This species inhabits the Galapagos Islands, and weighs sometimes as much as two hundred pounds. It affords an agreeable and wholesome article of diet. When it is desired to use one for food, Mr. Darwin says, an incision is made into the animal's skin near its tail, in order to ascertain if it is in good condition. If the expected quantity of fat is not observed, the creature is released, and is not at all put out of the way by the operation.

The marsh and river tortoises are found in most parts

of the world. Their shells are not of any use, but many of them afford a very agreeable article of diet. A small species called the Terapin, is occasionally imported into this country from America, and affords a very agreeable stew. It seems almost a pity that the taste for this kind of diet is not more general; as these creatures are very numerous, and are easily transported from their native haunts. Many of the little marsh tortoises are brought into this country, and sold for the purpose of adding additional interest to the fresh-water aquavivarium. It is, however, the group of marine tortoises, or turtles, that supply us with that great luxury of our city feasts, turtle soup. The species which is thus employed, is the green turtle (*Chelonia Midas*). It is principally found in the Atlantic Ocean, where it has a very wide geographical range. Allied species were known to the ancients, and it is said that Mercury took the first hint for the structure of a lyre from a turtle shell. Strabo and Pliny also inform us, that large turtles were used by people, who were called Chelonophagi, not only for food, but their shells for baths, boats, and roofs of houses. The way in which turtles are caught is very various; sometimes they are caught napping out at sea, and are then stuck and taken with a harpoon. A more common method is to watch for the females when they come on shore to deposit their eggs, and then to throw them on their backs before they can scramble back to the sea. Mr. Darwin gives a curious account of their capture at Keeling Island, where they occur in great numbers. They are chased out at sea by a boat, and when they are overtaken, a man jumps into the sea, and clings to the back of the

animal till it is exhausted with its struggles to disengage him; it is then taken into the boat. The Chinese make use of the Remora or sucking-fish to catch them. These fish are kept in tubs in a boat, and when a turtle is observed, they are put into the water with a string tied to their tails. No sooner does the fish see the turtle than it darts at it, and adheres so firmly to the shell by means of its sucking apparatus, that both fish and turtle are drawn into the boat by means of the string. These turtles weigh sometimes as much as five or six hundred pounds. The fat of turtles is an important article of commerce in some parts of the world. It is used as butter and oil in cooking, and also for dressing leather and for firing.

The shells of these animals are used for the same purposes as what is called tortoise-shell. It is, however, coarser, and not so valuable in the markets.

The true tortoise-shell is yielded by the Hawk's Bill Turtle (*Chelonia imbricata*). It also belongs to the group of marine tortoises. Most of the species are vegetable feeders, but this creature lives on small crustacea, mollusks, shell fishes, and the like. It is found in all the seas of warm climates, but principally in tropical oceans. An occasional straggler even arrives on our own shores, and it is duly described in local books on the natural history of the British Islands. The hawk's bill turtles have their favourite places of resort, where they go annually to deposit their eggs. The Island of Ascension is one of these fashionable resorts of the hawk's bill turtle, and here, as in fashionable places of human resort, thousands of turtles find it a place of destruction. At the same

time, travellers across the lonely ocean are often thrown into a state of excitement by the sight of a hawk's bill turtle many hundred leagues from land. The shell of this creature is imported every year in large quantities into this country. As much as thirty tons are annually consumed. Fashion, however, makes a great difference in the consumption of this shell. I was a few years ago at a comb manufactory in Sheffield, where I was informed that an unusual amount of activity was going on after years of depression. On inquiring the cause, I learned that her Majesty had visited the opera with a Jenny Lind comb in her hair, and this had made all the difference between almost starvation and a state of great prosperity to the poor combmakers of Sheffield. One cannot help seeing, through all the laws of supply and demand, the influence which taste and judgment can exercise on the various branches of our great national industry.

The parts of the turtle skeleton, which are used under the name of tortoise-shell, are the horn-like plates which cover the back shell or carapace of the animal — which is a truly epidermal appendage. Five large plates or "blades" are taken from the middle of the shell along the back, and four from each side. The rim of the carapace gives twenty-five small plates, which are termed the "feet" and "noses," whilst the other plates are called the "head" of the turtle. The size and thickness of the plates depend on the size and age of the turtle, a layer of horn being produced every year. These plates are generally of a yellow colour, mottled with brown. Plain yellow plates are in great demand. A

comb made from the latter is sold in Spain for three or four pounds, whilst the mottled sort is not worth more than twenty or thirty shillings. The horny plates are removed from the bone below by heating the shell, and separating them by means of a large knife. When manufactured, the horny plates are softened by boiling in water, to which salt is added. Two or more pieces of shell may be joined together by pressing them between plates of hot iron.

Tortoise-shell is manufactured into various articles for use. Its greatest consumption is for making ladies' side and back combs and dressing combs. It is also used for inlaying work-boxes, for spectacle-frames, and card-cases. It was formerly much employed for the handles of penknives and razors, but its use for these purposes is now very limited. Combs were formerly cut by the hand, but now a machine is used by which two combs are cut out of one piece.

But we must leave the reptiles and pass on to the birds. I need not stop to define birds. They are clothed with feathers, and this their distinctive character is one of their chief uses to man. Nevertheless I ought to remind you how useful birds are to man as sources of food. They are divided into seven great groups represented in the following diagram:—

1. Raptores.—Birds of Prey.

   Examples: Eagles, Vultures, Hawks, Owls.

2. Insessores—Perching birds.

   Examples: Crows, Larks, Blackbirds, Sparrows, Linnets, Canaries.

3. Scansores.—Climbing birds.

   Examples: Parrots, Woodpeckers.

4. Rasores.—Scratching birds.
   Examples: Turkeys, Barn-door fowls, Pheasants, Partridges.
5. Cursores.—Running birds.
   Examples: Ostrich, Rhea, Cassowary.
6. Grallatores.—Water birds.
   Examples: Flamingoes, Cranes, Herons.
7. Natatores.—Swimming birds.
   Examples: Ducks, Geese, Swans.

With the exception of the first, every one of these groups afford animals whose flesh may be eaten by man. Their eggs also serve as food. It is, however, more especially the rasorial and natatorial birds, that are domesticated by man to serve him for food. I have before alluded to oil* obtained from birds, and shall now confine myself to the uses of their feathers.

The structure of the feather is very much like that of the hair in the mammalia. It has, however, a more complicated structure. If we examine a feather, we can easily distinguish two parts. The lower part is hollow and without any fringes, whilst the upper part is solid and furnished with "laminæ or vanes" on each side. The feather is formed like the hair in a little follicle or capsule in the skin. In the early stages of growth, this capsule is occupied with a bulb, around which the feather is moulded. When the growth of the feather is completed the bulb dries up, and forms inside the lower part of the quill that loose mass which is known by the name of the "core." As the feather grows it is covered by the capsule, but this at last breaks, and the laminæ of the feather which had before been rolled together gradually unfold themselves.

* Lecture on "Soap," p. 124.

The feather is then attached to the skin by its lower part, but the capsule gradually wears away and the feather drops out. This is the process of "moulting." The colour and form of the feathers vary very much, and often determine their uses. In most birds the vanes of the feathers are supplied with little barbs at their edges, which lay hold of each other and give to the feather considerable power of resistance during flight. In some birds none of these barbules are observed, and the feathers have then a beautiful, soft, and light character, as in those of the ostrich. In the feathers of young birds and at the base of many others, the laminæ are of this kind, forming what is called down.

The colours of the feathers are sometimes most beautiful, and surpass in splendour all that the vegetable or animal kingdom can produce. As an example, I may refer to the little groups of humming birds. Nothing perhaps in the world exceeds in brilliancy and variety of colour the plumage of these tiny birds. At the same time we admit this, we should never forget, that we have been permitted to naturalize in this country a bird, which certainly has no compeer of its size in any quarter of the globe—I mean the peacock. That neck glowing with living green, and that tail with a galaxy of living eyes, is certainly not surpassed by any of the brilliant inhabitants of the forests of Asia, Africa, or Australia.

Feathers, then, so curious in their physical structure, so beautiful in their colours, are applied to a vast number of purposes by man. We may divide them into those which are used: 1, for quills; 2, for beds; 3, for clothes; 4, for ornaments; 5, for fishing.

First, with regard to writing. Although very generally used before and even since the invention of steel pens, quills do not seem to have been employed for the manufacture of pens till the sixth or seventh century. Previous to that time, and long after, reeds of various kinds were employed. For the purpose of making pens the feathers of various birds are employed. Those most commonly used are obtained from the goose; the five outer feathers of the wing being employed for this purpose. But these five feathers have different qualities; the first is round and hard, but short; the next two are the best, and the other two again inferior. Goose quills are employed for ordinary writing, but swan and turkeys' quills being larger are preferred for copying, whilst crow quills and duck quills are used for the finer descriptions of writing. The feather is usually plucked from the bird, and is then considered best, or those which are shed in May or June are employed. The quill end of the feather is covered with epidermal membrane, which is stripped off after heating.

Although the introduction of steel in the manufacture of pens has led to an enormous consumption, it does not appear to have diminished the demand for quills. In 1855 we imported into this country, independent of our home supply, 26,500,000 foreign goose and swan quills. The goose quills are worth from one to two pounds a thousand, and the swan quills from four to five pounds. One reason for the extensive uses of steel pens is undoubtedly the difficulty of mending quill pens. Recently, however, an instrument has been invented for this purpose, which requires but little skill in its use. I would advise those, moreover,

who write much to acquire the art of pen making, to use good quills and a fluent ink, and they will hardly regard metallic pens an improvement.

Who has not associated ideas of luxury with Eider Down? This substance is the product of the Eider Duck. It is brought to this country from the north of Europe, where it is found in immense numbers. It comes over in the form of balls of the size of a man's fist, and weighing three or four pounds. It is so fine and soft that if a ball is spread and warmed over hot coals, it will expand and fill a bed big enough for two persons. This down is of two kinds, "live" and "dead." The live down is procured from the nest of the duck, which robs its own breast to make a warm home for its young. The dead down is taken from the breast of the duck after it has been killed. There are many other birds that yield small down feathers, which are employed for stuffing beds, pillows, bolsters, and furniture. The feathers of geese, ducks, hens, and other poultry are used for this purpose. At the same time, however warm and soft these feathers may be, it should be remembered that their use is a source of danger. They readily absorb the secretions of the body, and frequently retain contagious poisons for a great length of time. Horse-hair mattresses are preferable for health. When feather-beds are used in a house, they should be cleansed at least once a year, and where persons have suffered upon them from contagious diseases they should never be used again till they are cleansed. The following is a process by which feathers are cleansed in one of the large houses in London :—

The feathers are first placed in what is termed a *steam*

cistern, a chamber of iron, having its floor formed of perforated metal, through which a current of steam is made to enter with considerable force to fill every portion of the cistern and thoroughly saturate the mass it contains; this continues for some time, the effect upon the feathers being analogous to that produced upon metallic substances when exposed to the red heat of a furnace. Every particle of animal matter they contain is fused and driven off, being carried away by the steam as it rushes through the mass and escapes by an aperture for the purpose in the roof of the cistern. The feathers, now, of course, in a damp state, are next placed in a large hollow cylinder of iron, into which, by means of a blowing machine, is carried a rapid current of air heated by a furnace to a temperature of 300°. This, like the first cylinder, contains a revolving instrument of iron, but having arms or bars of iron, and these, driven at a great velocity, pass through and through the mass, thoroughly separate it, and keep the feathers constantly in motion; thus allowing the current of hot and drying air to permeate them freely, and effectually separating every fibre of them; while, through a floor of wire, a large quantity of dust and refuse which must be disengaged passes away. Lastly, the feathers are placed in a hollow cylinder of perforated metal, in which revolves a "*fan,*" composed of four plates of metal fixed at equal distances from each other into a horizontal bar. This is driven with immense velocity, making about 900 revolutions in a minute, and carrying round the feathers with it; the dust, not already removed in

the drying cylinder, is separated by the powerful current of air which is driven through them, and, passing the perforations of the cylinder, is carried away by a drain beneath. By this means the feathers are rendered perfectly sweet, pure, and dry.

The annual quantity of bed-feathers used in the United Kingdom has been estimated at 700 tons, an enormous quantity when we recollect how light the material is.

Feathers are also used for clothing. In some parts of Arctic America the inhabitants make themselves coats of bird-skins which are worn with the feathers inside. The ancient Mexicans excelled in the art of plumagery, in which they appear to have followed the methods adopted by the Chinese. Confucius informs us that in remote antiquity, ere the art of weaving silk or hemp was understood, mankind were clothed with the skins of beasts and feathers. How the latter were held together is not stated, but it must have been in a rude manner by cords or thread. At a later period feathers were in general demand, as ornaments to banners and articles of attire; and, subsequently, for the manufacture of door-screens and caps. Tradition states that garments made of feathers, and resembling fur dresses, were presented to the Emperor Shauhau, who reigned twenty-five centuries before the Christian era. The earliest allusion to robes *woven* with feathers occurs in the history of the Tsin dynasty. In the year 272 A.D., Ching, the court physician, presented the emperor with a gown made of feathers from the golden-headed pheasant. The Emperor Wuti, who flourished in the latter part of the fifth century,

had a son who was notorious for his extravagance, having, among other costly articles, a robe woven with peacocks' feathers.

History further informs us that it was the custom of emperors to make presents every eleventh month, of robes made out of the feathers of the variegated kingfisher, to certain ministers of state. Again, at a later period, the imperial records state that the Princess Garluh engaged a skilful artificer to collect feathers of every description, to make of them two dresses, which should, when looked at in front, present one colour, when viewed sideways another, and when held up to the light, a third. When completed she presented them to the empress, and they were so much admired that the fabric became very fashionable among officers and the people, so much so that the hills and forests were swept clean of down and feathers, vast numbers of birds being ensnared for their plumage. Garments thus manufactured were necessarily rare, their use being confined to persons of rank and wealth; and it may be doubted if even among the Aztecs, whose country, unlike China, has vast forests crowded by the feathered tribes, the material was so abundant as to allow the inhabitants generally to shine in such borrowed plumes.

Old writers speak of the feathers of several kinds of birds being woven into a peculiar cloth by the Chinese. Among them was the celestial goose velvet, the foundation of the fabric being of silk, into which the feathers were ingeniously and skilfully interwoven on a common loom, those of a crimson hue being the most expensive. Of these wild-goose feathers two

kinds of cloth were made; one for winter, the other for summer wear. Rain could not moisten them; they were called "rain satin" and "rain gauze" respectively. Canton men imitated the manufacture, employing feathers of the common goose, blending them with cloth. This fabric, though inferior in quality, was much cheaper. Goods of the same description were also brought from Hohleh (believed to be Bokhara), made of birds' feathers; they were twilled, the crimson-coloured being most valued. The article was too heavy for garments. The Cantonese also learnt to imitate this, making it like plain silk, but inferior to that from abroad. Although the Chinese would seem to have lost the art of weaving feathers, plumagery is still extensively practised in the decoration of metallic ornaments worn by all classes of females, chiefly on the head. The gaudy lustre of the metal is softened by laying over portions of it a covering of blue feathers representing flowers, insects, birds, and the like, which imparts indescribable beauty to the silversmith's elaborate filagrees. The art appears to most advantage as practised by artificers whose occupation is the manufacture of garlands, chaplets, frontals, tiaras, and crowns of very thin copper, on which purple, dark, and light-blue feathers of gorgeous brilliancy are laid with exquisite taste and skill. A more tasteful, elegant, or gorgeous blending of art and nature than is exhibited in some of these head-dresses, perhaps no ingenuity has hitherto devised.

As this elegant art has not hitherto attracted much attention, I give the following account of it by Dr. MacGowan:—

"On the table at which the workman sits he has a fasciculus of feathers, a small furnace with a few embers for keeping warm a cup of glue, a small cutting-instrument like a screw-driver, a pencil or brush, and the articles—either silver-gilt, copper, tinsel, or pasteboard—which are to be feathered. The thumb and index-finger being smeared with glue, the feathers are gently drawn between them, which stiffens the barbs, causing them to adhere firmly together; and when dry the perpendicular blade is drawn close to the shaft, dividing it from the barbed portion. Holding this cutting implement as in writing, *à la Chinoise*, the artist, by pressing on the strips of barb with the knife, cuts them into the desired size and shape, which is a work of some delicacy—the pieces being very small, in the form of petals, scales, diamonds, squares, and the like, and requiring to be of the same size as the particular spot on which they are to be laid. Besides fingering this tool in the manner described, he holds the pencil nearly as we do a pen, dips it into the glue, brushes the spot to be coated; then expertly reversing it, touches with its opposite point a tiny bit of feather, which is thus lifted up and laid on the part for which it was fitted. Care is requisite, also, in giving a proper direction to this twilled work, for such, of course, is the appearance presented by the barbs. The feathers most in demand for this purpose are from a beautiful species of *Alcedo* brought from the tropical regions of Asia; they are employed for silver articles. King-fishers of coarser plumage and less brilliant hues found, throughout the country, are used for ornaments made of copper or pasteboard. Blue always greatly predominates over lighter or darker shades, relieved by purple, white, or yellow."

The skin of the swan is removed entire, and prepared in the same way as skins for furs. From four to five thousand swan skins are annually imported into this country. They are used for muffs and linings, and a variety of articles of dress. They are, however, expensive luxuries in a smoky town, as the delicate white of the swan-down soon becomes tarnished. The penguin is another bird whose skin is employed in dress, and sometimes the furs of animals are trimmed with the skin and feathers of the penguin. The mutton-bird, a species of puffin

(*Puffinus brevicandus*) which abounds on Flinder's Island, in the Pacific Ocean, is used for articles of dress. In the South Kensington Museum there is exhibited a lady's mantle, a victorine, a tippet, a muff, and cuffs, all made from the skin of this bird. The hackles of the turkey have been used for making muffs and victorines; and Mr. Booth, of Cork, by whom this invention was patented, exhibited such articles of dress at the Exhibition of 1851. The skin and feathers of the grebe (*Podiceps cristatus*) are also used for the same purposes, and muffs and boas of this material are not uncommonly worn. Mr. Roberts, of Regent Street, has made up the skins of other species of birds, and although not extensively worn as clothing, there is no doubt that both on account of their beauty and their warmth the skins of birds will be much more extensively worn than they have hitherto been.

The greatest variety, however, of feathers are used for purposes of ornament, and perhaps there are few things in creation more adapted for this object. Of those which are employed for ornament in Europe, there is no doubt that ostrich feathers bear the palm. The elegance of these feathers arises from their slender stems, and the loose vanes, which gracefully wave with every breath of air. The feathers from the African ostrich (*Struthio Camelus*) are most valued; those from the Rhea or American ostrich (*Rhea Americana*) being inferior in appearance. The feathers from the back are the best, then come those of the wings, and, lastly, those of the tail. They are scoured with soap and water, and bleached before they are worn. The barbs or fine branchlets are scraped with

glass, so as to make them curl gracefully. In 1855 10,000 lbs. of undressed feathers were imported into this country, of which about half were ostrich feathers. The fine white feathers are worth seven or eight guineas a pound. Fashion, moreover, has much to do with the price of all articles of ornament, and ostrich feathers are very fluctuating in their price. Ostrich feathers are dyed black, and are employed in this country as decorative articles on the most solemn of all occasions, that is, at funerals. Thus used they decorate horses' heads, or they are fixed on a coffin-board, and borne on the head of one of the undertaker's assistants at a funeral. A full set of the sombre plumes which are formed with the feathers is valued at from two to three hundred pounds. They are often dyed of other colours, when worn in head-dresses, as blue, green, red, and white tipped with pink.

The feathers of the Marabout, a gigantic crane whose terrible beak has punished so many children in the Zoological Gardens, are occasionally worn. They are brought from Cochin-China, and other parts of Asia where this bird is found. The most noble of our birds, the eagles, have magnificent feathers, but the colours are too sober to attract much attention. Nevertheless, the eagle's feather is worn in the hat and bonnet in Scotland. The Russians also employ them for decoration. A plume of eagles' feathers is worn as a mark of distinction by the Zulu Kaffirs in South Africa. The little heron (*Ardea garzetta*), is altogether one of the handsomest of its tribe. Its colour is of the purest white, and it is adorned with soft silky flowing plumes on the head, breast, and shoulders,

which gives to this bird a very peculiar beauty. The Turks and Persians embellish their turbans with these feathers, and they are not unfrequently worn in the head-dress by European ladies.

Cocks' feathers are worn in plumes by the soldiers in France. They are also worn by the American Indians, and are sometimes introduced into the hats of children and ladies in this country. Pheasants' feathers, the wing of the ptarmigan and the partridge, and of various other birds, are also used for the same purpose.

The wing and side feathers of the turkey are useful for trimmings and ornamental articles of dress, and have been made into victorines, boas, and muffs. Another better known article of commerce is the feathers of the bird of paradise, of which there are several varieties, distinguished by a peculiar union of splendour and elegance, and obtained almost exclusively in the archipelago islands near New Guinea. The beautiful wing and tail feathers of the Argus pheasant (*Argus giganteus*), which is found only in Sumatra and the Malayan peninsula, are also in request, as well as those of the peacock in China. Peacock feathers were at one time employed by Canton manufacturers in making variegated threads, which were used in forming beautiful articles for female attire. In China permission to wear the peacock's feather in the cap is, like the European orders, always specially granted to the individual wearer.

Feathers are more delicate in texture and more capable of assuming a variety of flower-like figures than many other materials. But a great difficulty

is encountered in dyeing them with due vivacity. The savages of South America manufacture perfect feather-flowers, derived from the brilliant plumage of their birds, which closely resemble the products of vegetation. The blossoms and leaves are admirable, and the colours never fade. The Italians frequently employ the cocoons of the silk-worm for that purpose: these take a brilliant dye, preserve their colour, and possess a transparent velvety appearance suitable for petals.

Artificial flowers made of feathers are now much used by ladies. Those from Madeira and the Brazils are most prized. They ought to be made entirely of undyed feathers, the best being those of a purple, copper, or crimson colour, from the breast and heads of humming-birds. The nuns of the convents in Madeira and of Solidad in Bahia are the principal manufacturers.

Before leaving feathers one must not forget to remember their contributions to the success of the "gentle art" of angling. It is by means of the feathers of birds that the "horrid hook" is made to assume the character of a fly. Much ingenuity is displayed in the manufacture of these artificial flies. In all cases they appear to be attempts at imitating insects, which are found on the surface of waters where fish abound, and they are adapted to every season of the year; from which it would appear, that fish are much too good entomologists to be taken in by a fly out of season.

Leaving now the lower animals, we must emerge again amongst the mammalia, where we shall continue

till the end of our course. In the last lecture, I gave you an outline of the orders into which this class of animals is divided. I shall only refer here to the orders to which the animals belong that supply us with their epidermal appendages, and first of all I shall speak of whalebone. But is whalebone an epidermal appendage? I hear some one say. Yes, it seems to be a sort of a feather or hair in the whale's mouth, not, however, to tickle it, but to serve a very good substantial purpose. It is not all whales that are furnished with this appendage. It is more particularly found in the common Greenland or whalebone whale (*Balæna Mysticetus*), the Antarctic or black whale, and the American whale. Other species, however, are caught, and their whalebone is used.

These animals have no teeth, and their place is supplied by rows of flat plates, ending in a fringe of bristles; these flat plates are the baleen or whalebone. There are two rows of these plates on each side the upper jaw, so that they hang down on each side of the tongue. Each of these rows, or "side of bone," as the whale fishers term it, consists of about three hundred of these plates of baleen or "blades." If you have examined the mouth of a whale you will recollect that it forms a kind of arch, so that the plates are longest in the middle and shorter on each side. Whales differ very much in size, and there are some of these plates twelve feet in length in the South Kensington Museum; sometimes the longer ones will reach fifteen feet in length, but the average length of the middle ones is about eight or ten feet. The average weight of these plates is about seven pounds, so that you see

a whale carries in his head about a ton of whalebone.

The growth of these plates is very curious. From their situation they might be regarded as modified teeth, but when we come to examine them we find that they are truly epidermal appendages. Dr. Gray has observed in the young whalebone whale the pulps of the true teeth, which are, however, never cut. The baleen is developed upon a kind of pulp like a hair. There are three parts observable, an inner, an outer, and intermediate portion. The baleen has a conical depression at its base, which is seated on the pulp, and the outside parts are developed from a mass of vessels surrounding the pulp. Like hairs, provision is made for their constant growth, and as they elongate they divide into bristles, which become finer at the end, and are constantly worn away.

Three principal kinds of whalebone or "fins," as they are called in the trade, are recognized in commerce: 1. The Greenland, from the Davis' Strait fishery and various parts of the North Sea; 2. The South Sea, or black fish whale-fin, brought by the South Sea whalers; and 3. The North-West Coast, or American whale-fin, obtained principally in the Pacific and Behrings' Straits fishery by the United States whalers. These three kinds are very different in shape, and are thus described by Dr. J. E. Gray:—

"The outer edge of the Greenland is curved considerably, in that of the North-West Coast it is much more straight, and in that of the South Sea nearly quite straight. The fibres on the edge, in the Greenland and margined whales, are very fine, flexible, and long, forming only a thin series; in the South Sea they are rather coarser; but in the North-West Coast much thicker and coarser, quite

bristly, and much more so towards the apex; and they are more erect, and form a thicker series, approaching in that character to the balleen of the 'finners.'

"The Greenland fin has the hair on its edge generally stripped off, and is clean and bright when it is brought to England; but this may be from the care the North Sea whalers take in collecting and cleaning it; and the blades are brought home in bundles of about 1 cwt. each. On the other hand, the North-West Coast fin, and the South Sea fin, have the hair left on the edges; they are brought home in bulk, and are always covered with an ashy-white, soft, laminar coat, looking like the rolled external layers of the enamel. This coat has to be scraped off with large knives before it is used or prepared, and the surface, after the scraping, is not so polished and resplendent as that of the Greenland 'fins.'"

The preparation of whalebone for use is very simple. It is boiled in water for about twelve hours, by which it becomes soft enough to be cut up, while hot, in lengths of different dimensions, according to the use to which it is to be applied; or by means of a compound guarded knife is cut into fibres or bristles for brushes of various kinds. In cutting up a blade, the workman examines the appearance of each strip or section, which he sorts according to length and quality as he proceeds.

The surface of the blade is compact, and susceptible of a high polish by mere friction. Its texture is lamellar in the direction of its breadth, so that it easily splits and divides in this direction, but not in that of the thickness of the blade. The middle of the blade is of a looser texture than the rest, and is technically called the grain, being composed of coarse bristly hairs. The general colour of whalebone is a dusky greyish black, intermixed with thin strips or layers of a paler colour, which are often almost white—very rarely the entire flake is milk-white. Whalebone that has been boiled, and becomes cold again, is harder and of a deeper

colour than at first; but the jet black whalebone has been dyed.

Artificial whalebone is now made from Rattan Cane (*Calamus verus* and other species), and takes its place for canes, for the stretchers and ribs for the frames of umbrellas and parasols, and for ladies' hoop skirts. The rattan is cleaned, trimmed, steamed, and dried, and then impregnated with some fluid, in which shellac forms a portion. It has now become so changed in its character as to be hardly distinguishable from the best quality of whalebone, except that it is somewhat more elastic and less liable to splinter and break. The name of Wallosin has been given to it.

The elasticity of whalebone, and the ready manner in which it can be worked, makes it serviceable for a great number of purposes. It is cut into quadrangular sticks for the ribs of umbrellas and parasols. It is made into staybones from twelve to sixteen inches long. The bristles are cut into lengths of different thicknesses for making brushes and brooms, chimney-sweeping and road-sweeping machines. It is used in thin strips for covering whip-handles, walking-sticks, telescopes and other articles. In thin strips it is plaited like straw and made into light hats and bonnets, whilst the fine shavings are employed by upholsterers as a stuffing for cushions, for filling fire-grates in summer, and other purposes. It is also used for making rosettes and servants' cockades. Solid pieces of different tints are twisted into walking-sticks, and last of all, it has been sometimes pressed into the service of that awfully dangerous article of dress called crinoline.

In previous lectures I have spoken of the other uses

to which these enormous animals are put. Such is the demand for oil, spermaceti, whalebone, and other cetaceous products, that the pursuit of them, it is feared, is leading to their gradual destruction. The returns from the whale-fishery in this country show a gradual decrease, and the same in the United States. The price also of whalebone has gradually increased. The cost of fitting out a ship for the whale-fishery is from twelve to fifteen thousand pounds, and the adventurer must wait for three years for the return of his capital. It is, nevertheless, in this dangerous trade that, both in England and the United States, a hardy and adventurous body of seamen has been reared, which are justly the pride of both countries.

I must now say a few words with regard to hair which is not wool. I must refer you to the lecture on wool, and that on furs, for an account of the structure of hair and of the uses of hair with the skin; but now I wish to speak of the uses of hair alone; and first there is human hair. It is not of much use when it is cut off the head as practised by the male portion of the population of Europe. These short bits, however, may be employed, and are sold to the bricklayer and plasterer and prussiate-of-potash maker. But the hair of young people is coveted by old ones; and the softer sex is more given to this form of coveting. Hair is the ornament of woman, and when lost she naturally seeks for an artificial supply. For this purpose human hair is made into curls, wigs, fronts, and ringlets. The hair for this purpose is obtained from the heads of young girls, and the supply in this country is chiefly derived from Germany and France. A head of hair weighs from eight to twelve

ounces, and, according to its colour, is worth from thirty to sixty shillings a pound. The light-coloured and most valuable hair comes from Germany, whilst the darker hair is supplied by the female peasantry of France. In those countries the girls look forward to the hair "harvest" for the means of purchasing trinkets and dresses. Human hair is also manufactured into a variety of articles of ornament, as bracelets, necklaces, watch-guards, brooches, rings, and many other things for personal adornment. The hair thus made up is frequently worn as a memorial of the person who supplied it. No less than from seven to eight thousand pounds' weight of human hair are imported into this country every year.

The long hair from the mane and tail of the horse is an important article of use. Besides that supplied by our own horses we import about 30,000 hundred-weights of horsehair every year. It is extensively used for military purposes, also for the stuffing of mattrasses and cushions of chairs, and a horsehair cloth of great durability and value is manufactured from it. The true crinoline petticoat is made of horsehair, hence it derives its name, but in this absurd article of dress our fair countrywomen have "sought out many inventions," and steel, whalebone, wadding, rattan-cane, and buckram supply the place of the genuine horsehair.

Horsehair differs in quality, the long straight hair being used for weaving, and the curled hair for stuffing purposes. Hair-seating is woven by hand, every hair being inserted singly. Horsehair fabrics are often mixed, and a warp of cotton and linen is used. These fabrics are sold cheaper, but are not so useful or durable

as the whole hair manufacture. Horsehair is sometimes used for ornamental purposes in other countries besides our own. A queue or tail of horsehair, suspended at the end of a pike, terminated by a gilded pennant, is the emblem of authority of a Turkish pacha of the third rank. Those of the first rank have three tails.

The hair of the ox, the cow, the elk, the goat, and the camel is extensively imported into this country and used for various purposes. Some of these hairs are capable of felting, and felt fabrics made without any weaving are very useful. Felt cloth is employed for clothing the pipes and boilers of steam-engines. It is also submitted to a process of tarring or bitumenising, which renders it waterproof. It is then excellent material for lining damp walls and roofs, and for covering buildings and ships' bottoms.

When hairs are large and strong they are called bristles, and are the principal material used in the manufacture of brushes. For these very useful epidermal appendages, we are indebted to the fertile soil of the pig's back. Hog's bristles are brought to this country from Germany, Russia, Denmark, and Poland. When taken from the animal's back they are of various colours, but they are sorted into black, gray, yellow, white, and lilac. These are frequently again re-sorted, according to the uses to which they are to be applied. Some idea of the importance of brush making as a trade may be formed by the quantities of thin bristles which are imported every year. In the three years previous to 1858, there were imported into England 2,500 tons of bristles.

From the bristle to the quill there is but a step. The hairs of the "fretful porcupine" grow into quills. As a specimen of an intermediate condition, the spines of the hedge-hog may be quoted. It would be interesting to know if possible, by what process of "natural selection" these enlarged hairs were produced on the backs of these animals. At present we only see that they are of great service in preserving them from the attacks of their enemies. The use of the hedge-hog's spines is confined to himself, but the quills of the porcupine are used by man. They are not abundant, and are consequently expensive. Their use is, however, limited. Penholders, work-piercers or eyeletteers for ladies, tooth-picks, fish floats, and even work-boxes are made with these quills.

I must next invite you to consider what in some points of view may be regarded as the most important of these natural skin products. We have seen that some of their appendages are of important use to the animal, whilst others again appear to be given entirely for ornament. The scales of the fish, and the feathers and hair of animals are necessary to their life, but we can but regard the feathers of the peacock and bird of paradise as intended for adornment. So it is with the hoofs and horns of which I am about to speak. Whilst the claws and hoofs are necessary for the existence of animals, the horns in almost every case appear to be supplementary to their natural wants. In the case of the mammalia from which these products are principally obtained, we find these appendages formed of the same materials, and on the same general principles as the hairs, the feathers, and the scales

which we have examined. The hoofs of horses and the various forms of ruminant animals are heavier, and less easily worked than horns, and are therefore not so useful. Nevertheless, we find that buttons, combs, and articles of similar use to those made from horn are made from hoofs, and when this cannot be effected, the hoof contains the same elements as those other skin products of which we have spoken, and can during their decomposition be usefully employed for manure, and the manufacture of prussiate of potash.

The hoofs of cattle are imported into this country, their annual value is from four to five thousand pounds. In their manufacture into buttons the hoofs are first thrown into a large cauldron, and boiled until they become soft, when they are cut in halves and sent to the workshop. Here are pierced or punched out the shapes or "blanks" by young women seated at hand-presses. The blanks, which are of a whitish colour, are then steeped in vats in a strong dye, either of black, red, or green, the only colours which the hoof will take; black being the most common colour. The shank is fixed by children while the blank is soft and hot. The button is then placed in a mould to take the under-surface impression, and heated over an oven until it is almost as soft as wax, when an upper mould with the pattern is placed upon it, and the two are subjected to the press, when the button comes out completely formed, only requiring a little paring to remove any roughness round the edges, resulting from the overflow of the molten substance. The buttons are then brushed and polished by steam-power, and are ready for carding and packing.

This material in its plastic state receives the most delicate impressions, and the buttons thus manufactured by Mr. Ingram, of Birmingham, are really models of the art of button-making. I understand they are not extensively sold. They are in fact not "fashionable," but if artistic merit were to guide our fashions, these handsome buttons would certainly take the place of the meaningless lumps with which our clothing is often bespattered or bespangled.

The horns of the mammalia are of various kinds. Thus, in the rhinoceros the horn is a mere appendage of the skin, and is formed of the hairs matted together. But generally horns consist of a prolongation of the frontal bones which form the axis or core. In the giraffe this bony protuberance continues covered with the skin; in other cases the skin drops off, as in the deer tribe, leaving the bony axis exposed; this annually falls off, and is termed an antler.

The horns of the sheep, the goat, the ox, and the antelope differ from those of the stag in being hollow. In all these animals a bony core, of a loose texture and conical figure, rises from the bone of the forehead, covered by a permanent vascular membrane, from the surface of which are produced or secreted thin layers of horn in constant succession. It is supposed that one layer, or rather one set of layers, is produced every year; but, as the former layer remains closely adherent to the new one, such horns are permanent, lamellar in texture, and exfoliate only very slowly from the outside by exposure to weather and friction. The structure of such horns is that of a number of cones or sheaths inserted into one another, the inner of which

lies on the vascular membrane that covers the bony core or base. The tip of the horn—namely, that part which projects beyond the core—is very dense, and the layers of which it is composed can hardly be distinguished; whereas the lower parts are of a looser structure, and the layers may readily be seen from the successive terminations of them forming prominent rings, which are very observable on the lower part of the horn.

In the manufacture of horn, the first process is the separation of the true horn from the bony core on which it is formed; for this purpose the entire horns are macerated in water for a month or six weeks, according to the temperature. During this time the membrane which lies between the core and the horn is destroyed by putrefaction, so that the core becomes loose, and can easily be extracted. The cores are not thrown away, but are burnt to ashes, and in this state form the best material for those small tests or cupels employed by the assayers of gold and silver. The next process is to cut off with a saw the tip of the horn, that is, the whole of its solid part, which is used by the cutlers for knife-handles, is turned into buttons, and sundry other purposes. The remainder of the horn is left entire, or is sawn across into lengths, according to the use for which it is destined. Next it is immersed in boiling-water for half an hour, by which it is softened, and, while hot, is held in the flame of a coal or wood fire, taking care to bring the inside as well as the outside of the horn, if from an old animal, in contact with the blaze. It is kept here till it acquires the temperature of melting lead, or thereabouts, and, in con-

sequence, becomes very soft. In this state it is slit lengthways by a strong-pointed knife, like a pruning-knife; and by means of two pairs of pincers applied, one to each end of the slit, the cylinder is opened nearly flat; these flats are now placed on their edges between alternate plates of iron, half an inch thick and eight inches square, previously heated and greased in a strong horizontal iron trough, and are powerfully compressed by means of wedges driven in at the ends.

The degree of compression is regulated by the use to which the horn is to be afterwards applied. When it is intended for the leaves of lanterns, the pressure must be sufficiently strong to break the grain, by which is meant separating, in a slight degree, the laminæ of which it is composed, so as to allow a round-pointed knife to be introduced between them in order to effect a complete separation.

The plates thus obtained are laid one by one on a board covered by bulls' hide, are fastened down by a wedge, and are then scraped with a draw-knife, having a wire edge turned by means of a steel rubber. When reduced to a proper thickness and smoothed, they are polished by a woollen rag dipped in charcoal dust, adding a little water from time to time; then rubbed with rottenstone, and finished with horn shavings. The longest and thinnest of the films, cut off by the draw-knife, when dyed and cut into various figures, are sold under the name of sensitive Chinese leaves, which, after exposure to damp air, will curl up as if alive, when laid on a warm hand or before the fire.

One of the great uses to which horn is put is the

manufacture of combs. For combs the plates of horn are pressed as little as possible, otherwise the teeth of the comb would be split at the points. They are shaped chiefly by means of rasps and scrapers of various forms after having been roughed out by a hatchet or saw; the teeth are cut by a double saw fixed in a back, the two blades being set to different depths, so that the first cuts the tooth only half-way down, and is followed by the other, which cuts to the full depth, the teeth are then finished, and pointed by triangular rasps.

If a comb or other article is too large to be made out of one piece of horn, two or more plates may be joined together by the dexterous application of a degree of heat sufficient to melt, but not to decompose the horn, assisted by a due degree of pressure; and when well managed, the place of juncture cannot be perceived. If a work in horn, such as one of the large combs worn by women, is required to be of a curved or wavy figure, it is finished flat, then put into boiling water till soft, and is immediately transferred to a die of hard wood, in which it is carefully pressed, and remains there till cold.

Horn combs ornamented with open-work are not made in this country, because the expense of cutting them would be more than the price of the article would repay; but great quantities are imported from France. These, however, are not cut, but pressed in steel dies which are made in London for the French market.

Horn is easily dyed by boiling it in infusions of various colouring ingredients, as we see in the horn lanterns made in China. In Europe it is chiefly coloured

of a rich red-brown, to imitate tortoise-shell, for combs and inlaid work. The usual mode of effecting this is to mix together pearl-ash, quick-lime, and litharge, with a sufficient quantity of water and a little pounded dragon's blood, and boil them together for half an hour. The compound is then applied hot on the parts required to be coloured, and remains on the surface till the colour has struck; on those parts where a deeper tinge is required, the composition is applied a second time. For a blacker brown the dragon's blood is omitted.

This process is nearly the same as that employed for giving a brown or black colour to white hair, and depends upon the combination of the sulphur, which is an essential ingredient in albumen, with the lead dissolved in the alkali, and thus introduced into the substance of the horn. The aggregate manufacture of combs in the United Kingdom has been recently estimated at 1,260 tons per annum in weight, and £320,000 in value.

Besides combs, horn is made into a variety of articles of use. The tips of buffalo and ox horns are made into umbrella and knife-handles, and for various uses by the optician. Cups are also extensively made of horn. The days of horn-books and horn-lanterns are gone by, but these articles still linger amongst us as memorials of by-gone days. Snuff-boxes, powder-horns, shoe-horns, table-spoons, and even plates are still made from horn.

However interesting in a natural history point of view it may be to go into a detailed account of the forms of horns, it would be impossible for me to

do so here. There is a very fine collection of horns at the South Kensington Museum. Many of them are not imported as regular articles of commerce, nevertheless there is scarcely any one of them that may not be applied to some useful or ornamental purpose. In the case exhibited by Messrs. Swaine, of Piccadilly, it will be seen that on account of its strength and elasticity the horn of the rhinoceros is used for the manufacture of whips and walking-sticks. This horn is regarded with superstitious reverence by the Mahomedans, and is employed as a charm against poison.

Rhinoceros horns are imported into Bombay from the eastern coast of Africa, Zanzibar, and the Somali coast, to be shipped to China, where they are used for making drinking-cups, the hilts of swords, snuff-boxes, &c. In the palmy days of Rome, we are told, the ladies of fashion used them in their baths to hold their essence-bottles and oils.

It is impossible to give very accurate details as to the imports of the several kinds of horns, for since 1847, when the duty was abolished, they have been all aggregated together. The imports of horns and tips, and pieces of horn, in 1855, amounted to 3,110 tons, valued at £88,386. The hoofs of cattle imported in that year were valued at £4,183. The import of buffalo horns and tips was probably about 1,400 tons (as 1,869 tons of horns of all kinds were received from the British East-India possessions). The value of buffalo horn varies from £25 to £35 per ton. From 600 to 800 tons are annually worked up in Sheffield, chiefly for cutlery handles and umbrella and parasol handle-tops, machete or cutlass-handles, scales, snuff-boxes, horn-stir-

rups, sword-handles, drawer-handles, dressing-combs, &c. Taking the average at 1,400 horns to the ton, the mortality among buffalos in the East to supply our manufacturing demands must be nearly a million a year, besides what may be required for continental and American use.

I must now direct your attention to the antlers of the deer tribe. It is the red deer (*Cervus Elephas*) that yields the stags'-horn principally known in commerce. The antlers of the red deer are really very beautiful objects. "The French call them 'bois,' and French naturalists have traced an analogy between these organs and the trunk and branches of a tree. They have even gone farther, and supposed that the materials which compose the antlers and those of the trunk and branches of a tree, are the same; so that some have even imagined that the skull of the deer was one of the spots in nature from whence we might pass by imperceptible gradation from the animal to the vegetable kingdom.

"The antlers of the deer tribe differ in their character from the horns of the other *Ruminantia*. They grow from the same part of the skull, but instead of horn are covered with a soft skin, termed the 'velvet.' This skin is covered with hair, but does not permanently remain enveloping the osseous part below. It has, therefore, been concluded that the velvet is like the conical part of the horn in the ox and the sheep, an extension of the skin and a part of the tegumentary system, whilst the antler itself has been regarded as a part of the osseous system or internal skeleton. The exuviation, however, of the antlers is a fact that seems to connect these organs with those parts of the skin, such

as hairs, nails, feathers, and scales, which are subject to this process. In fact, the antlers, like the teeth, seem to connect the two great systems of organs together, which are comprehended under the term skin and skeleton, and which in the *Tortoises* and some other animals are remarkably blended.

"The antlers generally commence their growth in the spring. A little protuberance is first observed on the frontal bone, which gradually increases in size. The blood-vessels which supply the bone and skin at this part enlarge, and as the horn becomes developed the carotid artery is observed to become larger. The horn is at first so vascular that the slightest prick or scratch causes it to bleed profusely. At this early stage it is nearly cylindrical. Gradually the antlers or branches are protruded, first those which are nearest the base, and subsequently those that are at the top. As the horn grows, the lower part or base expands, forming what is called the 'burr.' This is surrounded by a number of osseous tubercles, which grow faster than the velvet which covers them. It has been supposed, that in consequence of this growth of the burr, the blood-vessels of the velvet were pressed upon, and the supply of blood to this external covering was mechanically cut off. But the diminution and disappearance of the vessels of the horns depend on the same constitutional law which called them into existence. When the antlers have completed their growth, the vessels at the base of the velvet are entirely destroyed, and it begins to shrivel and peel off. In this state the antlers sometimes present a remarkable appearance, as the portions of velvet are seen flying from the horns like streamers. It

appears that this drying process is attended with a degree of irritation which the animal attempts to relieve by rubbing its horns against the trunks and branches of trees. This process is technically called 'burnishing,' and the tree against which a stag rubs its horns is called a 'fraying post.' As the older the stag the larger the tree he chooses to rub his horns against, there is an old forest proverb which says 'the greater the deer the larger its fraying post.'

"The horns begin to appear when the young stag is a twelvemonth old, and generally make their appearance in May and June. The horn has completed its growth in the month of August, and this is the time the 'burnishing' occurs. They remain upon the head till the following February or March. The circulation through the substance of the antlers being at an end, and the parts dead, the living body seeks to free itself from them, and a process of absorption of the matter between the head and the horns goes on till at last it falls off.

"The question has been asked what becomes of stags' horns after they are cast, and there is a very prevalent notion that the deer eat them. This has arisen from the few which are found compared with the numbers which are known to be thrown off. That both stags and hinds occasionally gnaw the horns is beyond doubt, and the yearning for a supply of phosphate of lime is probably the inducement to partake of this kind of food. Not only do the deer eat horns, but all the bones they meet with in the forest. It may also be added that where deer are, there are generally other animals, to whose welfare phosphate of lime is necessary, and who would assist in the same way in the de-

struction of the fallen antlers. In the case of the horns of the red deer found in the ossiferous caves of Great Britain there can be little doubt from their number that the horns alone were brought in by the carnivorous animals as food, as they all gave indications of having been gnawed. The horns are also often dug out of bogs and morasses, where they have been deposited by the stags, who, often to allay the excitement and irritability attendant upon the loosening of the horn, thrust their heads into any soft ground they may be near. This practice seems to have given origin to the name of a small lake near Fort William, which is called Loch-chabar, or the Lake of the Horns, from the number found in the soft black moss by which the lake is surrounded. In cases where the horns are dropped in the woods or on open ground exposed to atmospheric influences, they would soon begin to decompose, and in the course of three or four years they would entirely disappear.

"The number of tiers or branches of the horn varies according to the age of the animal. The first that is shed is straight and single, like a small thrust-sword or dagger, whence the young male is called a 'daguet' by the French; at the beginning of this period it is called in Britain a 'knobber;' at the end of the year it is called a 'brocket.' The primary branch of the horn is called the 'beam.' The second horn that appears has usually but one antler; this antler, which is nearest the base, is called the brow-antler. The animal is now called a 'spayad.' It sometimes happens that two and even three antlers appear with the second horn. The second antler is called, in the

language of 'Vénerie,' the 'bez-antler;' the third is called the 'royal,' the subsequent eight the 'sur-royal.' The third horn has three or four antlers, and sometimes as many as five or six. When the bez-antler appears, which is usually in the fourth year, the young Stag is called a 'staggard.' The fourth pair of horns do not usually exceed in the number of their branches those of the third. When the third antler appears, which is called the royal, the animal is usually in its fifth year, when it is called a 'Stag.' The fifth horn bears five or six antlers. These form part of the sur-royal, and the animal now becomes a 'Hart.' The sixth horn which the stag sheds in its seventh year has usually a larger number of branches than that of the preceding year. The stag is now said to be 'croched,' 'palmed,' or 'crowned.' In French it is a 'Cerf de dix cours,' in English a 'Stag of ten, 'twelve,' or any other number of branches the horn possesses. When the number of branches reaches sixteen, the stag is called a 'Great Hart,' and the head is said to be 'summed of its points.' Should an increase take place on this number, he is said to be 'summed of eighteen,' 'twenty,' or any other number of points to which he may attain. At the present day, the oldest stags in Scotland seldom present more than ten or twelve points. At the same time, many living sportsmen have killed stags with thirteen, fourteen, fifteen, and sixteen points. There is a head still preserved at Mauritzberg, which presents the enormous number of sixty-six points; it was killed by the first King of Prussia, and presented by that monarch to Augustus, Elector of

Saxony and King of Poland. In the collection at the Château of Wohrad, the hunting residence of the Lordship of Frauenberg, there are one hundred and nine stags' heads, of which only seventeen are under fourteen points.

"The size and the number of points developed, depend in some measure on external circumstances. Where the animal is in good condition, and has abundance of food, and is free from disturbance and external annoyance, there the horns will develope to their utmost. Where animals have but indifferent pasturage and are driven to exist where food is scarce, there the horns diminish in size and produce fewer points. It is on this account that in Scotland those deer have the finest heads that are confined to the forests; as it is a general rule, though not without exception, that the best pasturage is found in woods or their neighbourhood.

"The horns of the stag are often injured during their growth by catching in trees, fighting, and other causes. If any injury occurs to the blood-vessels on one side, and not on the other, thus diminishing the supply of blood, the horn on the injured side is invariably less than the other.

"The form of the horns differs at different ages; but it is not easy to tell the age of a stag by its horns. Up to the eighth or ninth year the density of the horns increases, and from that to the twelfth year the horns are in greatest perfection. When stags become fat, their horns have been observed to diminish in size, and in the number of their points. As they become older they get thinner, and the general

deficiency of nutrition acts upon the horns. When the stags are young, the points of the horns are softer and more spongy than when older, and the number and softness of the points are a tolerable criterion of age up to the eighth year. After this period the degree of sharpness of the points indicates the age of a stag.

"There is a very prevalent belief that the horns of deer differ in form in different forests. This difference, however, does not appear to have been reduced to any fixed law. It is probable that the only real difference depends upon the character of the food to which the animals have access, and which we have already seen is capable of affecting their size by limiting or increasing the supply of the materials out of which the horns are formed.

"The colour of horns differs somewhat. In old stags they are generally darkest, and differ in colour in different forests. This has been supposed to arise from their getting stained by the trees on which they rub off the velvet. This, however, is doubtful. Whatever be the colour of the rest of the horn, the points are always white and smooth as though they had been polished.

"The horns of the stag are thrown off in April or May. This process is technically called 'mewing.' It does not, however, depend on the formation of the new horns, which begin to make their appearance from eight to ten days after the former horns are cast. The older the stag is, the earlier he begins to cast his horns, so that in some instances they are lost as early as February, and sometimes as late as May.

The velvet disappears in August or the beginning of September, just previous to the commencement of the rutting season. These periods appear to be affected by the food; for as a rule, the best fed and pastured animals produce their horns, have them in perfection, and cast them sooner than those which are deficiently fed or nourished.

"There are not wanting many instances in the animal kingdom of the female assuming male attire; and amongst the deer the female of the rein-deer is supplied with horns equally with the males, but in no one instance does it appear that the hind of the red-deer was ever observed to have horns."*

The antlers of the deer are employed for making a variety of useful and ornamental articles. It is only the old horns that are used. When young they are so soft and tender as to be entirely useless. In Switzerland the stag's horn is manufactured into a variety of ornamental articles for wear, such as brooches, pins, bracelets, and many other things. In Sheffield they are used for the handles of knives and other cutlery purposes. The whole shaft of the horn is used for making the handles of carving knives, whilst they are cut up into small plates and riveted on to an iron case for the handles of pocket and pen knives.

The stag-horn used in Sheffield for cutlery purposes is chiefly supplied from Hindostan and Ceylon, about 400 tons per annum being received from these sources, and from Bombay and Madras. 100 to 200 tons of horns, chiefly stag, are shipped annually from Colombo,

* Notes on the Deer of Scotland, by E. Lankester, M.D., in Macgillivray's "Natural History of Dee Side," 1855.

Ceylon. In addition, 100 tons, or more, are received annually from the continent, obtained in Germany, Russia, Spain, and Italy, and from our own parks, and other sources. The supply from Germany lessens each year as the forests decrease and the native cutlery manufacture extends. With the exception of the elk (not yet extinct in Germany, and having the largest of horns), the deer-tribe have horns heavy and solid in proportion to the heat of the climate in which they are produced. The horns dropped on the hills and plains of India and Ceylon are very heavy, and almost as solid as bone. From Southern Russia we have deer-horns lighter than the Indian, but heavier than the German, and the reindeer horn from Norway and Lapland is lighter and more pithy than the German. It is, however, much less valuable as the surface is white and quite smooth.

Taking the imports from the East at but 350 tons, and the average weight at 1,400 to the ton, it appears that the "fall" (as it is termed), from 240,000 head of deer is annually collected in India for Sheffield use.

About 26,000 pairs of horns are annually shipped from Siam, and in Greenland about 18,000 head of deer are annually killed. There is also a considerable destruction of deer in North America. It does not appear that the antlers of our own deer come in any quantities into our markets. The horns of the deer killed in the Highlands of Scotland are generally prized by the sportsman as trophies of his success, and are hung up in the hall or some other conspicuous place.

I must, however, now draw my remarks on the uses of these epidermal appendages to a close. It is

important to all to know and appreciate the value of these things as articles of use and commerce. The comfort and happiness of mankind are increased just in proportion as they come to understand that the special products of one portion of the earth may be exchanged for the special products of another. In this way the good gifts of Providence are laid open to all, and man himself has his intellectual qualities developed and his social condition ameliorated by the commerce that is thus established.

ON ANIMAL PERFUMES.

I HAVE taken for my text in this lecture Animal Perfumes, but I shall speak generally of those substances and forces which are produced by the animal, but which do not form part of its body. There is a great difference in this respect between animals and plants. Animals seem to be constantly employed in undoing what plants have done. They consume vegetable food of all kinds, and their life seems to be the result of letting loose the forces which it was the object of the plant to render quiescent. The plant exposes in its tissues the elements of carbonic acid and ammonia to the light and heat of the sun, and so they become converted into starch, and sugar, and fat, and protein as food for man and beast; they are

charged with all manner of colours, and odours, and substances with medicinal properties. But now these substances, held together by the changed forces of light and heat, are introduced into the animal body, they are again changed, and heat, light, electricity, and life are the result. Whilst these forces are being set free, man uses them, especially the vital force, to effect the objects of his life before they pass into other forms of force less available for his wants. Whilst these great changes are going on in the body as the result of the common processes of eating and drinking, a thousand subsidiary chemical processes go on, and thus substances are formed in the animal body which we do not meet with in the plant. The chemistry, however, of the animal body is weak and feeble as compared with that of the plant. The function of the one is to build up, whilst the other is to destroy. The quiet energies of the vegetable kingdom are for ever employed in building up the materials, which remain but for a moment as part of the fabric of the animal body, but in passing away produce the force which we see in the life of the animal kingdom. This is a beautiful circle of change, and when once it has been rightly grasped by the mind, it gives the highest possible interest to every fact connected with the great changes which go on in this passage of matter, from the time that it is picked up from the dust of the ground, till it becomes the minister of man's highest faculties.

Of the forces which are the result of chemical change going on in the animal body, no one is used so largely and extensively as the muscular force. From the earliest

times, man has used animals for the purpose of transporting himself and his productions from place to place, and in the business of moving the machinery he has invented. Thus muscular force in animals differs in no respect in its results from the force obtained by the aid of steam and machinery, since its origin is the same. The animal partakes of vegetable matter for its food, just as fuel is necessary for fire, and the chemical changes involved in the oxidation of the food and the fuel result in the communication of motive force. I shall not, however, dwell here on the beasts of burden used by man. The horse, above all other animals, by its strength and docility has been employed in all parts of the world, both for swift locomotion and hard work. In the east and many countries of Europe the ox is harnessed to the plough. The slow moving elephant is found most useful amongst the indolent inhabitants of tropical Asia. The camel is strong, and enduring thirst for lengthened periods is adapted for the use of those people whose intercourse require that they should traverse arid plains. The llama is employed in Peru, the dog in Greenland, and the reindeer in Lapland. Such are a few of the illustrations of the application of animal force to the uses of man.

I know of no instance in which animal heat is immediately used by man, but as a proof of the identity of animal heat, and the heat of ordinary combustion, I would remind you, that we can hatch birds' eggs by the aid of artificial heat. When also the heat of the animal body fails, we can restore it by exposing it to artificial heat, and we eat our food and drink our beverages artificially heated to prevent the loss of our animal heat.

Another form of force which is found in certain exceptional cases in the animal kingdom, is electricity. It has been known from a very early period in the history of mankind, that certain fishes found in the Mediterranean have the power of producing convulsions in the human body. The fish thus endowed were called cramp-fish or torpedoes. In the middle of the last century it was found that this property depended on electricity. Leyden jars were filled with electricity by the aid of these creatures, and all the phenomena they

Fig. 2.

presented were accounted for upon the known laws of electrical action. This curious faculty was found to be connected with the nervous system of the animal, which communicates directly with its electrical apparatus, situated on each side of its body. (Fig. 2.) There can be no doubt that we have in this phenomenon a direct conversion of the nervous force into electrical force.

Many years after these facts had been made out in the torpedo, Humboldt announced that he had discovered in the fresh-water lakes of Mexico a species of eel possessed of the same properties. These eels (*Gymnotus electricus*) are much more tenacious of life than the torpedoes, hence opportunities have frequently presented themselves of studying the properties of these creatures. One of these electric eels was exhibited for many years at the Polytechnic Institution in London, where it amused spectators by displaying the extraordinary paralysing effect of its electrical discharges upon the live fish on which it was fed.

I could, however, have hardly spoken of these electrical fishes being useful to man if it had not been for the recent discovery of an electrical fish in the rivers of Malabar. This creature belongs to an entirely different family from the other two, and is named the *Malapterurus Malabaricus*. In the Nile and the rivers of Central Africa there is another species of *Malapterurus*, known by the name of the Thunder-fish, which has the power of giving electric shocks. But the fish from Malabar has been recently sent to Europe by the Scotch missionaries in that country, and has excited a good deal of interest on account of its small size and shocking habits. According to an account of this fish given by the late Dr. George Wilson, of Edinburgh, before the British Association for the Advancement of Science at Dublin, it has been known from time immemorial to the inhabitants of Malabar, and they have not only known its electrical powers, but have used it as an electrical machine. It is on this ground that Dr. George Wilson claims for this fish the credit of being

the earliest form of electrical machine used by mankind. It is used both medically and morally, and for these purposes a tub is appropriated to the reception of the Malapterurus in every household. When persons are affected with paralysis, rheumatism, or other diseases, the part affected is placed in the water with the fish; a shock is soon received, and in this way it really seems to exert a beneficial influence. But it is morally that it is of the greatest use. It appears that the Malabar children, like all other children, require occasionally punishment for their misdeeds, and instead of using the rod or birch so common amongst European barbarians, they employ a dip into the tub with the Malapterurus. It is said to be most effectual, a child being seldom known to be very disobedient after one of these shocking experiments.

Of the chemical compounds which are formed in animals, and which are called secretions, the most interesting and curious are those which are employed as perfumes. It is somewhat difficult to distinguish the difference between substances that give off disagreeable odours and those which give off pleasant ones. For, practically, we find that some things which are disagreeable in large quantities are pleasant in small ones. Odours, also, like flavours, address themselves to peculiarities of taste, and what is disliked by some people is enjoyed by others. In some countries the smell of putrid fish is regarded as particularly pleasant, and even in Great Britain there are not wanting persons who prefer their game high. We are very much the creatures of habit both in taste and smell, and the perfumes and flavours which we should have rejected in

the unsophisticated period of childhood, we seek after as indulgences in more mature age. Noxious and disgusting as is the smell of burning tobacco to those unaccustomed to it, there are those amongst us who cherish it more than does the African his putrid fish. The choice of perfumes, then, is entirely a matter of taste, and in those we choose to employ from the animal kingdom, we shall find that they very closely approach in their nature the volatile particles to which we apply the inelegant term "stink." When speaking of the furs of animals, I had to refer to some creatures which give out most atrocious odours. The fox, the pole-cat, and the skunk, are most remarkable for this property. It is known, however, to all persons who have kept animals, that quite independent of the gases given off in the decomposition of the materials rejected from the body, they have peculiar odours. Now some of these odours have found favour in the noses of our fair countrywomen, and in spite of the objectionable idea, they consume in very perceptible quantities every year the scents given off by the civet, the musk-deer, the beaver, the whale, and other animals.

As we know too little of the nature of these odours to classify them according to their composition, in speaking of them I shall merely follow a natural history classification, and bring before you, first, the Civet Cat (*Viverra*). (Fig. 1.) There are three species belonging to this genus which yield the perfume known by the name of civet; two are inhabitants of Asia, and the other of Africa. The latter is the most common, and, I believe, our British supplies of the article are mostly derived

from the African species. These animals belong to the carnivorous division of the Mammalia, and are first cousins to the weasels, martens, and pole-cats, that we spoke of in the lecture on furs. The viverras or civets are known by the large size of the pouch which secretes the peculiar odoriferous substance for which they are esteemed. This pouch is divided into two bags, and is situated at the back of the animal, beneath its tail. The interior of the bags possess a glandular structure, which separates the odoriferous matter from the blood of the animal. This substance is of a pale yellow or brownish colour, and of the consistence of honey. It possesses a somewhat acrid taste, and when brought close to the nose has, to most persons, a very disagreeable smell. It is not unlike musk, but the odour is stronger and more powerful, although its diffusive properties are not so great. When mixed with butter, lard, wax, or alcohol, in the proportion of one part to the thousand, the offensive character of the odour is altogether lost, and it becomes aromatic, fragrant, and even delicate. It is in this way that it is employed in perfumes, and it has also the peculiar property of rendering more evident other scents with which it is mixed. Lavender and other scented waters are rendered more pleasant by the skilful addition of minute quantities of civet.

The African civet is from two to three feet long, and from ten to twelve inches high, and has a tail half as long as its body. In its habits it resembles the foxes and smaller cats, attacking birds at night. In captivity it is always dangerous. It is, nevertheless, domesticated in Africa for the sake of its perfume.

It is also imported alive into Holland, where it is kept for the same purpose. The animal is enclosed in small cages, in which it cannot turn round, and in this way the scent is easily removed from its pouches. It has been observed that the secretion is formed in greater abundance when the animal is irritated: this clearly shows that the secretion is under the influence of the nervous system, and is probably intended for purposes of defence against its enemies. Whether this be the case or not amongst the civets, there can be no doubt of the fact with regard to the skunk and the pole-cat.

There is a civet cat in Java (*Viverra Rasse*), called the Rasse. Dr. Horsfield, who has described it, says, it is more savage than the other species of Viverra. It is, nevertheless, kept in Java for the sake of its perfume, which is a great favourite amongst the Javanese. They use it in the form of essences for their clothes and unguents for their persons. Even the apartments and furniture of natives of rank are scented with it, frequently to such a degree as to be offensive to Europeans.

The *Viverra Zibetha*, the civet cat of the continent of Asia, is found from Arabia to Malabar, and in the large islands of the Indian Archipelago. It is much milder in its disposition than the rasse, and is domesticated by the Arabs and the Malays who inhabit the coasts of Borneo, Macassar, and other Asiatic islands. It is said to be more tameable than the African species, and in some of its habits it resembles our domestic cat.

Civet is not so much used as a perfume by itself in this country as it used to be. It is not often that

one has to exclaim with the gallant in Massinger's play:—

"Lady, I would descend to kiss thy hand,
But that 'tis gloved, and civet makes me sick."

Even in Cowper's time, the use of civet was very extensive, and exposed those who employed it to his satire:—

"I cannot talk with civet in the room,
A fine puss gentleman that's all perfume,
The sight's enough, indeed, to smell a beau
Who thrusts his nose into a raree-show."

At the present day it is considered a reproach to "smell like a Muscovy cat." Nevertheless, civet is consumed in considerable quantities in this country, and as much as forty shillings an ounce is paid for it.

Musk is another of these animal perfumes. It is the most powerful scent known, and the power a single grain has of making its presence evident to the olfactory nerves, is frequently referred to as a proof of the divisibility of matter. The animal which produces it is a ruminant, a species of deer, called the Musk Deer (*Moschus moschiferus*). It is about the size of a roebuck and inhabits the mountains of China, Thibet, Tonquin, Teute, and Siberia. It is a shy animal, and fond of precipices covered with pines and almost inaccessible crags. Hence the hunter of the musk-deer often endangers his life in the perilous chase. At the same time large numbers of these animals are annually killed, on account of the value of the musk. One traveller speaks of having purchased in one journey 7,673 musk-bags, and the annual import of musk into England, is 10,000 ounces. The bag or pouch which contains this sub-

stance, is placed on the under side of the creature, and is peculiar to the male. This bag opens by two little holes, which when pressed allow the musk to exude. It has at first the consistence of honey, and has a brown colour and an unctuous feel. When the musk is dry it is of a dark-brown colour, inclining to red or a rusty black, and appears more or less granulated. The musk-bag varies much in size and shape according to the age of the animal, and the time of the year at which it is procured. The older the animal the more valuable the musk. The secretion is also known to have a much stronger odour in animals that inhabit Thibet and China, than those which are found further north in Siberia. Although the musky odour penetrates the whole animal, the flesh of both male and female are eaten by the inhabitants of the north of Asia. Musk is brought into this country in two forms, and is known as Tonquin or Thibet musk, and Kabardin, Russian, or Siberian musk.

The Tonquin, or Thibet Musk, is received through the East Indies, and is brought into this country in small oblong rectangular boxes, which are lined with lead, to prevent the escape of the odour. They are generally covered with paper, but sometimes silk. These little boxes contain the musk-bags, or pouches, which are wrapped up with thin blue or red paper having Chinese characters upon it. Sometimes the bag is enveloped in a deep yellow or brownish paper, which becomes very brittle by keeping. On unfolding this paper the pouch is found of a dark-brown colour. It is slightly flattened, and of a conical or pear-shaped form. It is covered with hairs, some of which are

long and others short. In some specimens the outside longer hairs have been cut off, whilst the finer, less bristly, dark, firmer hairs remain in their place. The hairs generally lie converged towards the little narrow opening in the pod. The pods are about two inches and a half long, and about an inch and three-quarters broad. The weight of different specimens varies very considerably, some not exceeding half an ounce, whilst others will weigh considerably above two ounces. The average quantity of the real musk which can be removed from these pouches is about one hundred and ninety grains. The musk is found lining the pouch in the form of little grains of different sizes, of a reddish-brown colour, and having an unctuous feel. These grains are often mixed with hairs which are derived from the inner side of the little natural orifice in the pouch.

The Kabardin, Russian, or Siberian musk is very inferior to the Tonquin. It either comes direct from St. Petersburgh or through China, where it is sent for the purpose of being laid in contact with the Thibet musk, in order to acquire its scent. The pods of this musk are larger, more oval, and more compressed than the other. The colour of the hairs is also lighter, and the musk exhibits a smoother and less granular appearance. The odour is much less penerating, and it is altogether a very inferior article to the Thibet musk.

There is also a third kind of musk brought into the markets, and is supposed to be the produce of a species of musk-deer known by the name of *Moschus Altaicus*. The pouch is perfectly round, and the hairs outside are of a yellowish-brown colour.

The composition of musk does not throw any light on its peculiarly odoriferous nature. The following is a list of the substances found in it:—

A volatile principle.	A peculiar bitter principle.
Ammonia.	Osmazone, with salts.
An uncrystallizable acid.	Fungoid matter.
Stearine and Oleine.	Sand.
Cholesterine.	Water.

The odour of musk is very penetrating, and has the power of enduring for a long time. Like civet, also, it has the power of disseminating other odours. A molecule of musk appears to give its diffusibility when in contact with them, to molecules of otto of roses, oil of neroli, and other delicious perfumes. A grain of musk will give a perceptible odour to 3,000 grains of any inodorous powder. When kept it should be preserved in stoppered bottles. It is more soluble in water than in alcohol. Of one hundred parts, ninety are soluble in water, whilst only fifty are soluble in alcohol. It is also soluble in ether, in vinegar, and in the white of egg.

Musk is much more powerful when moistened than when dry, hence it has been supposed that the scent results from a kind of fermentation or decomposition in some of the constituents of the musk. The odour is also very powerfully increased by mixing the musk with alkaline salts, especially the carbonate of potass. When kept in capsules of wax it almost entirely loses its odour. It also loses its smell when placed in contact with lime, milk of sulphur, sulphide of gold, or milk of almonds. Under all these circumstances, however, the musk is restored to its original smell

by the addition of a little spirit of hartshorn, the *liquor ammoniæ* of the druggists and doctors.

There are other species of Moschus which produce the pouches with the musk in them, but they are none of them so efficient as the *Moschus moschiferus*. Other animals give out a musky odour, which is probably due to the same principle as that which produces musk, but which occurs in all parts of the body. Thus the crocodile has a strong smell of musk, and also other species of Saurian reptiles. There are two species of marine turtle (*Chelonia caouana* and *C. caretta*), which have a strong smell of musk, and their oil is valued on account of this smell. A species of ox (*Bos moschatus*), found in North America, is called musk-ox on account of its flesh having a musky odour. Sir John Richardson tells us, that this odour is much more manifest in the lean than in the fat kine, and that in the latter it does not interfere with the flavour when cooked. I have before spoken of the musk-rat, the skin of which comes over from North America in such large quantities. At certain seasons of the year this creature smells strongly of musk. There is also among insects, a gnat called *Tissula moschifera*, which gives forth a very decided smell of musk.

Nor is this odour confined to the animal kingdom for we are all acquainted with the little musk-plant (*Mimulus moschatus*), which is sold in the streets of London on account of the pleasant odour of its leaves. The common beet (*Beta vulgaris*), gives out an odour of musk. There is a species of larkspur (*Delphinium glaciale*), which grows on the slopes of the Himalayas at a height of 17,000 feet, and which smells so strongly

of musk, that the natives believe that the musk-deer gets its musk from eating this plant. Dr. Hooker also describes another species of larkspur which grows on the Himalayas, and gives out a powerful musky odour. A vegetable remedy which is used in the same cases as musk and called Sumbul, has a very strong and enduring odour of musk. The Arabs add to their coffee the seeds of the *Abelmoschus moschatus* on account of their musky odour.

From all these facts, one is led to conclude, that musk depends on some combination of elements which is not very uncommon in the animal and vegetable kingdoms, and that the time will probably soon come, when the chemist will be able to manufacture it in his laboratory. This prospect is, I think, warranted, when we consider that some odours found to be common to both animal and vegetable substances have been found by the chemist. As an instance, I may mention the compound known to chemists by the name *trimethylamine*. This is one of those remarkable bodies formed by substituting one set of elements for another, and perhaps as an illustration of a large series of highly interesting chemical bodies, which probably enters largely into the composition of animal perfumes, I may be permitted to describe its nature. Now you have all heard of ammonia, and probably know that it is composed of three atoms of hydrogen with one of nitrogen. You have also all heard of wood-spirit, and that it is composed of a compound radical called methyle. Now, the chemist can take this methyle (composed of two atoms of carbon and three of hydrogen) out of the wood-spirit, and put it into the place of the hydrogen of the ammonia. So that

then we have an ammonia composed of three atoms of methyle, with one of nitrogen instead of three atoms of hydrogen. Thus:—

Ammonia.	Trimethylamine.
$\left.\begin{array}{l} H \\ H \\ H \end{array}\right\} N.$	$\left.\begin{array}{l} C_2\ H_3 \\ C_2\ H_3 \\ C_2\ H_3 \end{array}\right\} N.$

This then is trimethylamine, and a very disagreeable compound it is. It is found in the stinking goosefoot (*Chenopodium olidum*), and gives to that plant its very disagreeable odour. By distilling the plant you can get the trimethylamine. Now the smell of this substance is precisely like that of stinking fish, and if you take decaying fish, especially if they have been salted, and distil them, you will get trimethylamine. It is probably this substance that gives to fish their well known general flavour, and Professor Johnston suggests in his "Chemistry of Common Life," that it might answer for the cook to give a fish flavour to savoury patties by the addition of a spice of trimethylamine.

Another of these animal substances used in medicine is the secretion called castoreum. It is produced by the common beaver, the use of whose skin and hair I referred to in a previous lecture. The castoreum, as it is called, is secreted in the interior of a little bag or pouch, with which these animals are supplied, and is found in both the male and female. In the living animal this substance presents itself as an unctuous, almost fluid substance, of a brown colour, and having a very penetrating and disagreeably fœtid odour. The castoreum is brought into the markets in the same manner

as the musk, in the pouch or pod, in which it is originally located.

Castoreum differs according to its age and the age of the animal from which it has been procured. When kept for a long time it loses much of its odour, and with that its medicinal properties. Two sorts of castoreum are found in the markets, one from Russia and one from America. The latter is again known by the name of Canadian and Hudson's Bay castoreum. Of these varieties the Russian is the best. By boiling Russian castoreum in alcohol, and evaporating the solution, a crystalline body is obtained which is called castorine, and is supposed to contain all the active properties of the castoreum.

I am not aware that this substance exerts any specific influence on the human system. It is, however, employed in the same diseases and to effect the same purposes as musk, assafœtida, valerian, and other powerfully-smelling medicines. These substances appear to produce the same effect on the body as ammonia and alcohol, but their effects are not so transient as the first of these remedies nor so injurious as the last.

Another of these animal secretions is hyraceum. This substance has very much the smell and the chemical and physical properties of castoreum. It is brought from the Cape of Good Hope and other parts of Africa inhabited by the Cape hog (*Hyrax Capensis*). It is not, however, procured from the animal but from its haunts. It has not, like the previous animal, a special pouch for the production of this substance, and there is still some doubt as to its true nature. There is no *doubt*, however, of its animal nature and of its con-

taining one of those definite compounds which form the basis of powerful scents.

The last of these animal products of any commercial value is the substance known by the name of ambergris. It is a solid opaque substance of a bright gray colour, darkest externally, and intermixed with yellow or reddish striæ. When first taken into the hand it has little or no smell, but on being heated or rubbed it exhales an odour of a peculiar kind and which is agreeable to most persons. It is more or less soft, so that it sometimes yields to pressure with the fingers. When broken it frequently presents a lamellar structure, as though it had been deposited by layers around a central nucleus. At other times it consists of less regular deposits and assumes a granular appearance. It has a specific gravity less than water, and is not unfrequently found floating on the sea. It occurs in the seas of warm climates. The best specimens are brought from Madagascar, Surinam, and Japan. It occurs in masses, weighing from a few ounces to several pounds. Kæmpfer, the Dutch naturalist, tells us that he once saw a piece weighing 180 pounds, and another piece is spoken of as having been sold to the Dutch East-India Company, weighing 185 pounds. You may form some idea of the value of this substance when I tell you that this celebrated piece of ambergris was sold for two thousand pounds sterling.

The origin of this substance has been a fertile theme for speculation. Some of the older writers regarded it as a kind of condensed foam of the sea, others that it was a resin or gum, or a kind of bitumen. Some have regarded it as a vegetable production, whilst others have

more rightly judged it to be of an animal nature. There seems to be little doubt at the present day that it is formed in the interior of the body of the whale, and more particularly of the spermaceti whale. It is not, however, a constant product in these animals, and would appear to depend on the nature of their food. It may be, therefore, looked upon as a secreted product, and to resemble in its general nature those hard bodies found in the gall-bladder, known by the name of gall-stones. It is supposed that its peculiar scent is given to it by species of cuttle-fish and other mollusca, which are known to have a musky odour.

When chemically examined, ambergris yields a peculiar principle called ambrein. This substance is obtained by heating ambergris in alcohol, which, on cooling, lets fall small colourless crystals which have the smell of ambergris. It also contains benzoic acid and common salt. Ambergris is used medicinally in the East, but in this country it is used exclusively for the purposes of perfumery. Only small quantities appear to find their way into this country. It still fetches a very high price; and I saw, a few months since, a piece, in the possession of Messrs. Piesse and Lubin, valued at above one hundred and fifty pounds. It is, like the other animal perfumes, more valuable as a basis for other scents than having any special merits of its own.

Amongst animal products, long fallen into disrepute in this country, but nevertheless having a great reputation in some parts of the world, are what are called "bezoars" or bezoar-stones. This word is derived from the Persian, and signifies the poison-expeller, which will give you a capital idea of the value attached to

these stones. They are all found in the alimentary canal of some animals, and are regarded as antidotes to all poisons, and to possess other extraordinary virtues. They belong to the class of remedies to which we refer: the charms, and amulets, the king's touch of bygone days, and the infinitesimal doses of the present. We sometimes congratulate ourselves on the progress of science, and pity our ancestors or the rude inhabitants of Africa for their belief in witchcraft and the occult powers of minerals and the courses of the stars, but we shut our eyes to the ignorance and superstition of the present day, which entertains the belief in the efficacy of doses of infinite nothingness and the influence of the world of spirits in making tables to dance and deal floors to talk. These bezoars then obtained their celebrity from imaginary virtues. The most valued of them were obtained from the *Capra ægagrus*, or wild goat of Persia, and this kind of bezoar was called "*Lapis Bezoar Orientalis*." They obtained a high price, and are even now valued as curiosities. Such concretions, however, are not uncommon in the stomachs of other animals. They are gradually formed around some central point or nucleus, and the hard layers consist principally of phosphate and carbonate of lime. Sometimes a mass of hairs are agglutinated together in the stomach of animals, and this is frequently the case with the cow, which, whilst suckling the calf, licks off the hair from its back. The hairs, not being acted on by the digestive fluids, collect together in round balls, which are sometimes of considerable size. Even these at one time had believers in their virtues, and they were administered as remedies for disease.

It might not be uninteresting, if my time permitted, to point out to you how numerous have been the animal products which in past times have had commercial value on account of their supposed virtues as remedies in disease. In many of these cases it seems that the more disgusting the remedy the more virtue was attached to its action on the body. M. Moquin Tandon, in his Medical Zoology, a work recently translated into English by Mr. Hulme, has given a list of these animal medicines which are no longer employed. We find in this list that toads, spiders, scorpions, worms, fleas, bugs, ants, and lice were prescribed to be swallowed whole alive or in powder. Snails, cockroaches, and worms were boiled in milk or oil. The blood and fat of monkeys, dogs, lions, elephants, and all sorts of animals were prescribed in many diseases. The hairs of cats and dogs, the feathers of birds, the teeth of wolves and cod-fish, the livers of porcupines, bears, and frogs, the kidneys of donkeys, and a long catalogue of other absurd remedies entered into the ancient materia medica. One could afford to laugh at these things if the thought did not occur that many of our popular remedies at the present day have nothing more to recommend them. People get ill, they take the prescribed dose and get well, and forthwith come to the unphilosophical conclusion that they have got well on account of the remedy. In some of these instances they may be thankful they have got well at all, as it is very manifest when we inquire into the nature of the remedy that they must have got well in spite of it. The fact is that the majority of diseases have a tendency to terminate in health. They are actions in the

system which can seldom be controlled, as is the popular notion, by specific remedies, and all they require is that the body should have fair play and all obstacles to recovery removed. It is only when remedies have a known peculiar action on the body that any beneficial effect can be referred to their action in disease.

Before leaving this subject of animal odours, I would allude to those scents which are given off from the animal matters in a state of decomposition, and which seem to be produced to act as warnings to our senses of the dangers which lurk near. These stinks, as we vulgarly call them, are dependent on a variety of compounds, but more especially sulphuretted hydrogen and ammonia. Such compounds are produced by the taking to pieces of the original matter. I have already told you that all organic bodies are more or less composed of the four elements, carbon, hydrogen, nitrogen, and oxygen. With these is frequently combined the element sulphur. In breaking up, in returning to their original mineral condition in contact with the oxygen of the air, or without, they form various gases. The sulphur combines with hydrogen, forming sulphuretted hydrogen; and the nitrogen unites with hydrogen, forming ammonia. These compounds in themselves are harmless enough. Sulphuretted hydrogen is the distinctive quality of many of our mineral waters, and is drunk almost with impunity. Ammonia is the base of smelling salts, and is continually administered as a medicine. It is, therefore, not these gases that do the harm. Nevertheless, they are given off in states and conditions of matter that are capable of doing immense harm. Disease is

constantly found lingering in the neighbourhood of decomposing animal and vegetable matter. Of course I am now particularly concerned with animal matter, but I would remind you that the deadly malaria of tropical forests, that the poison which spreads disease throughout the length and breath of America, is essentially vegetable in its nature, and arises from the decomposition of vegetable matter. But a no less deadly property attaches to the poison of animal matter. Typhoid fever, erysipelas, and a variety of diseases have been traced directly to decomposing animal matter, and I will not stop to inquire here, whether these diseases are the direct result of the introduction of a poisonous animal matter into the system, or whether they induce a predisposition in the system to take in these particular forms of disease. There is evidence, I think, to shew that these animal poisons act both as direct sources of disease, and as causes of predisposition in the system to certain diseases. I cannot tell you the nature of these poisons, they have not been separated and examined. Whether like the lower plants they are composed of cells, which are capable of multiplying in the system, or like chemical compounds as diastase, they are capable of communicating their own state of change to the system, we are still in the dark. But we know that they exist, and we know, moreover, that one of the signs of their existence in animal matter is the presence of sulphuretted hydrogen and ammonia. These gases may exist without the poison, and the poison may exist without the gases. It therefore behoves us to look carefully to our dwellings, lest we are exposing ourselves to any of

these deadly emanations. They may be almost defied in the open air, but what is most to be dreaded, is their stealing into the dwelling-house, finding their way from sewers, and drains, and cess-pools, by rat-holes, and cracks, and crevices into the sitting-rooms and bedrooms of our houses. It is here where they do their deadly work, both in inducing and predisposing to disease.

It is then of the greatest importance to our health, that all animal matter should be either at once removed from the vicinity of our houses, burned, or deodorised and disinfected. These very compounds, so deadly to ourselves, are fertilizers of the soil, and the substances capable of producing disease and death during their decomposition are capable of yielding the elements by which plants furnish nutriment to man and beast. In cases where the speedy removal of these compounds in the form of manure is rendered impossible, they may be rendered comparatively innoxious by the aid of deodorising and disinfecting agents. Several of these agents are the basis of popular remedies used for this purpose.

One of the most efficient of these agents is chlorine. It combines readily with hydrogen, and thus speedily decomposes organic compounds. It takes away at once the smell of sulphuretted hydrogen, and forms with ammonia an inodorous compound. It destroys the germs of animal and vegetable life, and reduces the compounds with which it is mixed to a quiescent state. It is used in the form of chlorinated lime, or chloride of lime as it is called, and in combination with iron, zinc, and manganese, has entered into the com-

position of many of the deodorising and disinfecting liquids that are sold for use.

Oxygen is another powerful deodoriser. It combines with hydrogen to form water; with nitrogen to form nitric acid; with carbon to form carbonic acid; and a free exposure to the oxygen of the atmosphere speedily destroys the dangerous qualities of decomposing animal substances. In the form of ozone it is more active than any other. It is on this account that the salts of permanganic acid, which contains ozone, are so efficient as disinfectants. The ozone of the permanganic acid seizes on the organic matter, and is decomposed. Thus the beautiful colour of the permanganates is speedily destroyed by organic matter, and I have recommended them on this account, as tests for the presence of organic matter in water.

Another of these agents is carbolic acid. This is obtained from coal-tar and other sources; it is contained in creosote, and is a most effectual means of arresting decomposition. It may be used either in a liquid form or combined with some absorbent powder, and then applied to sources of disagreeable effluvia. So great is the power of carbolic acid in arresting decomposition, that one gallon of the impure acid will render inodorous thirty thousand gallons of sewage.

Another powerful agent in effecting the same beneficial object is charcoal. Of all forms of charcoal that obtained from the slow combustion of animal matter is best. Hence animal charcoal is most to be recommended for this purpose. It is especially applicable to the purification of water in which organic matters are

diffused, and which frequently produce disastrous effects when not thus treated. The charcoal seems to act not as a filterer or strainer, but by exposing the particles of organic matter to the action of oxygen, and reducing them to the inorganic compounds of which I have before spoken. Vegetable mould seems to possess the same properties, and where no other disinfectant can be had recourse to, may be most efficiently applied for this purpose. This seems to be one of those great natural relations by which man is taught that the safest and most advantageous way of disposing of animal refuse is to mix it with the soil, where it at once becomes deprived of its injurious properties, and is rendered valuable as a manure.

Closely allied to the mephitic vapours which produce the various forms of malarious and intermittent fever, and predispose to other diseased states of the system, are those definite animal poisons which engender such diseases as small-pox, scarlet-fever, measles, and others. In these cases an animal poison generates a specific disease, which disease alone is capable of reproducing the poison. Such poisons resemble those lower forms of plants whose spores we find blown about by the air, and ready to attack any plant that may be ready to receive them. These animal poisons are generated quite independent of dirt and filth, although they undoubtedly find a fitting soil for their development in human systems surrounded by these accessories. It is, moreover, a mistake to suppose that mere cleanliness will prevent the access of these poisons. The cabin of the destitute and the palace of the rich are alike accessible to these fevers, and it is

only by their entire destruction that any class of the community can expect to escape their devastating influence. Yet these poisons are to be got rid of. I am credibly informed that neither New Zealand or Australia have yet been invaded by small-pox. We see by these examples what may be done. Stop these poisons; root them up as you would a vile weed in your garden or farm, and they will be arrested. They have an origin in the beginning of things, and, like the dodo and the Irish elk, they may become extinct, no more to be renewed. Like the wolf and many other of our wild animals, they may become annihilated, and it is for the highest interests of society that this should be known. We have, I trust, got rid of plague from this country, and I see no reason why we should not get rid of typhus and small-pox, of scarlet-fever and measles. But it must be done by exterminating the vital germs of these diseases, which are now allowed to sow themselves with impunity in every family of the land, and scarcely an effort is made by an ignorant and deluded public to resist their influence. Nay, more, we are even taught by those high in authority, that these poisons are the offspring of decomposing animal and vegetable matter, and the source of their virulence and activity is thus lost sight of altogether.

But I must now draw my course to an end. I have endeavoured to make these lectures subservient to the objects for which the animal product collection at South Kensington was got together. That collection was the offspring of the Great Exhibition of 1851. It was presented by the Commissioners of that Exhibition to the nation as the nucleus of a trade collection to be

devoted to the exhibition of the raw material and manufactured products of the animal kngdoms. Feeling that a Museum without intelligent instruction is like a school-room supplied with books and other implements of education, without a schoolmaster, I have undertaken to supply in these lectures that information which, I think, the public has a right to demand in every institution professedly devoted to educational objects. It is only by a systematic training in the principles of the natural sciences involved in their occupations that we can expect our working men or their masters to execute their work with all that skill and economy of which their industry is susceptible. By the present system of working by the rule of thumb, an enormous waste of energy and labour is daily taking place, which, if properly economized according to natural laws, would produce an exuberance of comfort, and even luxury, where now only squalor and suffering present themselves. The knowledge of natural laws is the first great condition of man's existence and advancement. It is in vain for him to cultivate the dead literature of the past if he is negligent of the overflowing life of the present. He lives in the presence of forces which, if he does not master them and make them his servants, they will master him and he will be their slave. Nor is it the culture of art that will save him from the terrible presence of the powers that everywhere threaten his existence. His palace, however beautiful, must be built in accordance with the laws of gravitation; the material of his most cherished forms of beauty must be constructed in accordance with chemical laws; his actions, however graceful, must be made

in accordance with physiological laws, or the whole must perish. It is for us in these times to cherish, as the most precious gifts of Providence, those discoveries of genius in the domain of natural science which distinguish the civilization of our age. In those discoveries we have the key to unlock the great secrets by which our existence is bound up with the laws of the Universe. It is just as we study these laws and apply them to the varied purposes of our life, that we shall be able to lead that existence which is the highest dignity of man, and realize those blessings which a knowledge of that which is true can alone confer.

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